



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

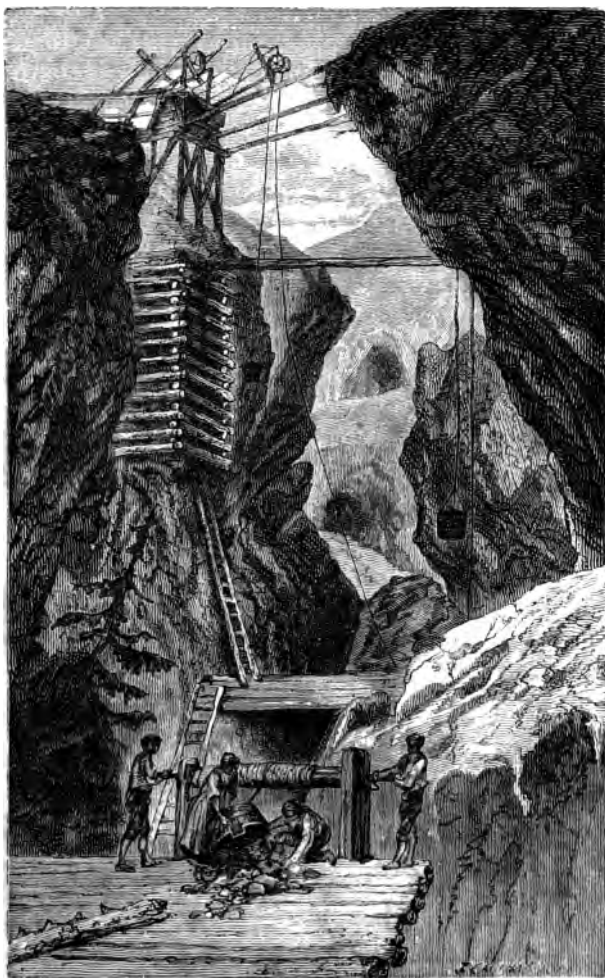
Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

BENEATH THE SURFACE
OR THE
WONDERS OF THE UNDERGROUND WORLD

WITH 10 ILLUSTRATIONS







SILVER-MINE OF KONIGSBERG, NORWAY.

BENEATH THE SURFACE;

OR, THE

WONDERS OF THE UNDERGROUND WORLD.

By

W. H. DAVENPORT ADAMS.

"The earth,
Though, in comparison of heaven, so small,
Nor glistening may of solid good contain
More plenty than the sun that barren shines."

MILTON.



LONDON:

T. NELSON AND SONS, PATERNOSTER ROW;
EDINBURGH; AND NEW YORK.

1876.

188. 9. 43.

P R E F A C E.

IN the following pages an attempt is made to furnish the reader with a comprehensive and exact description of the structure of the Earth's crust, of the fossils enclosed within its various formations, of its metallic deposits, and its stores of mineral wealth. Special chapters are devoted to the interesting and suggestive subjects of springs and fountains, and grottoes and caverns, the most remarkable of which are indicated, while their legends and associations are brought together. The salts and natural gases, fumeroles, and chalybeate waters, as well as other remarkable features of the world "beneath the surface," are also duly noticed. The reader is conducted in turn to the coal-mines of Northumberland, the marble-quarries of Carrara, the sandstone-quarries of Fontainebleau, the tin-mines of Cornwall, the lead-mines of Allenhead, the oil-wells of the United States and Canada ; and particulars are given

of the character and habits of the miner and quarryman, of the nature and extent of the important industries which depend upon their labours. Underground life has its perils, and these are recorded ; the underground world has its wonders, and these are put before the reader.

It is believed that the information thus collected contains much that is calculated to interest and astonish, and that to many it will supply an entirely novel idea of the treasures that lie "beneath the surface."

The facts set forth have been carefully gathered from trustworthy sources ; but it is necessary to mention the writer's special indebtedness to Simonin's "Le Monde Souterrain," Tissandier's "La Houille," and Badin's "Les Grottes et Cavernes." Also, to Lubbock's "Prehistoric Man," Lyell's "Principles of Geology," Nicholson's "Manual of Paleontology," and the works of Lartet, Walter White, E. Hull, Tomlinson, Poulett Scrope, and Dr. Daubeny. As an introduction to a valuable and interesting study, it is hoped this little volume will be found useful, while the general reader will probably find in its pages something that he could not easily find elsewhere.

W. H. D. A.

CONTENTS.

CHAPTER I.

THE WORLD ON WHICH WE LIVE.

Compared to a house—Supposed sea or lake of fire—What are igneous rocks?—The earth's crust examined—Its formations and periods—Successive developments of animal and vegetable life—Fossils, and theories about them—The "medals of creation"—The Maestricht cavern—Bone-caves—Something about Fossil Man—Proposed explorations "Beneath the Surface"..... II

CHAPTER II.

PREHISTORIC MAN.

A definition of "Fossil Man"—The earth an extinct sun, on which the waters have built up continents, and life has undergone various evolutions—Fossil Man and Prehistoric Man considered—Researches of the earlier geologists—Curious error as to the "homo diluvii testis"—The Anthropolithes—Opinion of Cuvier—The Bone-caves and their treasures—Objections and objectors—M. Boucher de Perthes—Stone-hatchets of the valley of the Somme—The celebrated "jaw" discovered at Moulin-Quignon—A Scientific Congress—Vol—Menhecourt—Fabricators of flint-weapons—The miller Quignon—Discoveries of M. Lartet—Discoveries in Belgium, England, Germany, Italy, and America—Inferences deducible from well-authenticated facts..... 38

CHAPTER III.

UNDERGROUND—METALLIC DEPOSITS AND THEIR FORMATIONS.

Sedimentary and eruptive rocks—Metamorphic rocks—Veins of metal—Theories of Descartes and Werner—Metallic deposits of the Primary, Secondary, Ter-

tiary, and Quaternary rocks—Ribbon-like veins—Veins of contact—Metaliferous strata—Eruptive veins—Deposits in the drift—The mine: Roof, walls, and galleries—Condition of the metallic ore in the veins—The metaliferous chain of the Andes—Discovery of the silver-mines of Spain and the gold-mines of California—An unfortunate expedition—The commercial value of the Minerals and Metals—The Chinese—A Brilliant Transaction at Madagascar—How to secure a net profit of five millions. 59

CHAPTER IV.

THE SALTS AND NATURAL GASES.

The great family of minerals—Old superstitions—The good old days of lithology—The seven members of the mineral family—Part played by each of them—The saline springs of the Carpathians and the Val-di-Cecina—The alum pits of Montioni—Fumeroles of boric acid—The Styx and Charon's boat—Sulphurous springs—Chalybeate springs—Petrifying waters and dropping wells. 100

CHAPTER V.

SPRINGS, SOURCES, AND FOUNTAINS.

Origin of Springs—From Lucretius—Phenomena of rain—Explanatory remarks—Capriciousness of rain—Statistics of the rainfall in different localities—Water and scenery—The Fountain of Arethusa—A legend—Palestine a "land of springs"—The course of streams—Springs in the granite formation—Fountain of Vaucluse—Fountain of Nîmes—St. Winifred's Well—Fets and wells—Fresh-water springs out at sea—Intermittent springs—Siloam—Mineral springs—Carlsbad—Kissingen—Vichy—Barèges—Aix-la-Chapelle—Spa—The German baths—Baths in the Pyrenees—Hot waters of Bath—Tunbridge Wells. 166

CHAPTER VI.

GROTTOES AND CAVERNS.

Celebrated caverns—That of Trophonius—Description by Pausanias—Mystic ceremonies—The famous oracle—Livadhia—Grotto of the Cumæan Sibyl—The Blue Grotto at Capri—Grotto of St. Rosalia—Grottoes with religious traditions—Caves always used as places of retreat and sanctuary—Grottoes of Spagari—Caverns in France—Grotto of Longara, in Italy—Grotto of Camoëns, at Macao—Salt-mine caverns of Wieliczka—Fingal's Cave—Grotto of the Cheeses—Cave of Petchabury—Grotto of Monsummano—Grotto of La Madeleine—Marine grottoes and caverns:—Caves of Crozon—Cave of Morgatte—Grottoes of Etretat—Grotto of Bonifacio—Grotto of

CONTENTS.

ix

Torghatten—S. Michael's Cavern—Scratchell's Cave—Grottoes of Tournane—Caves produced by subterranean currents:—The Devil's Hole—Grotto of Adelsberg—Grottoes of Sassenage—Sundry caverns excavated by subterranean currents—Natural bridges—Stalactitic grottoes:—Antiparos—Grotto of La Bausne—Grottoes of Arcy—Grottoes of Osselles—Grotto of Han-sur-Lesse—Mammoth Caves of Kentucky—Alabaster cavern of California—Grottoes and caverns with concretions not calcareous—Their origin—Ice-caves and natural glaciers—At the abbey of Grace Dieu—Ice-cave of Vergy—Artificial ice-cave of St. Ouen—Bone-caves:—In England—In France—In Belgium—Germany—Caverns in which human bones have been exhumed..... 207

CHAPTER VII.

COAL AND COAL-MINES.

Formation of coal—Growth of peat—Submarine forests—Reconstruction of the primeval world—Resemblance of the African forests to those of the ancient coal-measures—Deposit of coal—Development of the beds—Early history of coal as a combustible—Production of coal in Belgium—The United States—Coal in Great Britain—In Central Europe—In France—In Africa—In Hindustan—Some statistics—Coal-basins—Discovery of their position—Excavating a coal-mine—Working a coal-mine—Various systems in various countries—Life in the coal-mines—The miner: his labours, habits, and character—Perils "beneath the surface"—Choke-damp and fire-damp—A catastrophe at Mons—Landslips and floods—An anecdote—Tragedies in the coal-pits—The calamity at Lalle—A record of accidents—A liquid combustible—Petroleum—Oil-wells in the United States and Canada—Their variable product—The story of Shaw, the American—A catastrophe at Idiona—Uses of petroleum—Attempts to employ it as a combustible—Petroleum and steam navigation—The present and the future of coal—Diminution of the coal supplies of Great Britain—Probable discovery of a substitute for coal..... 375

CHAPTER VIII.

QUARRIES AND QUARRYMEN.

Mineral industry: its origin—Army of workers employed by it—Quarries and quarrymen—Slate quarries—Quarries of alabaster and marble—Quarries at Volterra—Carrara and its marbles—Roman quarry at Polvaccio—Valley of Ravaccione—The Concha—A visit to the works—The saw-mill—Marble works at Marseilles—Filfila—The Carrarese sculptors—Manufacturers of imitations and copies—Academy of Carrara—Roman quarry at Colonnata—Historical details—The quarries of Paris—Geological description—Gradual formation of the Paris basin—Its present character—

istics—Erratic blocks—Occurrence of a great natural revolution—Strata of the Paris basin—Chalk—Clay—Shell limestone—Ancient history of the Parisian quarries—Used as Catacombs—Quarries now at work—Plaster of Paris: what it is—How it is worked—The American quarries and their marls—The Sandstones of Fontainebleau—The workmen of the quarries—An anecdote—A story from Iury—The “Gouapeurs”—Conclusion 441

CHAPTER IX.

THE GREAT MINES: TIN, LEAD, AND IRON.

Tin: its value as a metal—Tin-mines of Spain and Germany—In China—Tin in Great Britain—Antiquity of the tin trade—The Cornish tin-mines—Copper—The Botallack mine—The Cornish miners—Reduction of the tin ore—Gold as a metal—Gold in England—Gold extracted from lead—The lands of gold—Silver—The silver-mines—Lead—The lead-mines of Great Britain—A visit to Allenhead—Going down a lead-mine—The miners and their habits—Value of iron—The antiquity of this metal—Iron in Great Britain—Iron-mines of South Wales—An impressive scene—Description of a blast furnace—Iron-producing districts—The end 508

BENEATH THE SURFACE.

CHAPTER I.

THE WORLD ON WHICH WE LIVE.

Compared to a house—Supposed sea or lake of fire—What are igneous rocks?—The earth's crust examined—Its formations and periods—Successive developments of animal and vegetable life—Fossils, and theories about them—The "medals of creation"—The Maestricht cavern—Bone-caves—Something about Fossil Man—Proposed explorations "beneath the surface."

T is necessary that we should introduce the reader to the underground world, the world "beneath the surface," before we attempt a description of its phenomena.

It forms the lower stage of the earth which we inhabit; and the configuration and character of the upper world are, to a certain extent, regulated by the physical economy of the under. Here are laid the foundations of the glorious palace which man is permitted to inhabit; here are stored the materials which furnish him with so many comforts, luxuries, appliances. It is the storehouse, or treasury, in which are accumulated the metals and minerals, the water-power, and the igneous action, which play so important a part in our human history.

On a sea or lake of fire, whose shores are composed of solid materials, rests the first continuous crust of the little sphere which carries on its surface Man and all his fortunes. This crust consists of the granites and other massive crystalline rocks, which geologists call *igneous*, because their formation is supposed to have been due to the agency of fire.

Such is, at least, the hypothesis now *generally* accepted. About a quarter of a century ago, it was the belief of *all* geologists that the granites were produced by igneous action, like those seething molten lavas which the volcanoes of the present age eject from the interior of the earth. But a new geological school has arisen, which repudiates this theory, and asserts that water—though water, it is true, at a very high temperature—was the sole agent in their formation. This hypothesis, however, lacks the merit of novelty; it was put forward, towards the close of the last century, by the German geologist Werner, and was then known as the distinctive principle of the Neptunian in opposition to the Plutonian theory.

We recommend the reader to regard both theories as possessing elements of truth, and to adopt the classification of the most exact and least speculative geological authorities, who divide all the rocks entering into the stratification of the solid crust of the earth into two great classes: *Igneous*, and *Aqueous*.

The *igneous* rocks are those formed *within* the body of the earth by the action of fire.

The *aqueous*, also called *sedimentary*, are those deposited on the terrestrial *surface* by the action of water.

The former are generally found lying in unstratified masses ; the latter, arranged in distinct strata, or layers, like courses of masonry.

From the granites and porphyries, which form, as it were, the foundation and basement of our terrestrial habitation, we ascend to the first stage, where the sedimentary rocks begin. These, as we have said, are distinguished by their regular stratification ; by their disposition in distinct layers or strata.

Such strata may be confined to a single material—as in a block of sandstone—or composed of more than one. When examined over a sufficient space, they invariably present a series of alternate layers of different mineral composition.

As to their origin, a recent writer remarks that they are, for the most part, “derivative” rocks ; in other words, they are derived from the attrition and trituration of pre-existent matter. Sometimes, however, they are the result of chemical or vital action ; and it is in this case that they are most accurately described as *aqueous rocks*. With reference to the mode of their deposit, it would seem that the materials composing them were formerly distributed through the agency of water ; because a similar process is being worked out in our own day at the mouths of tidal estuaries and great rivers, and, indeed, wherever water is in motion. Not a woodland stream, which poet has celebrated and fable hallowed, but, as it flows onward “for ever and for ever,” carries with its current a burden of mud, sand, and rounded pebble, “derived”

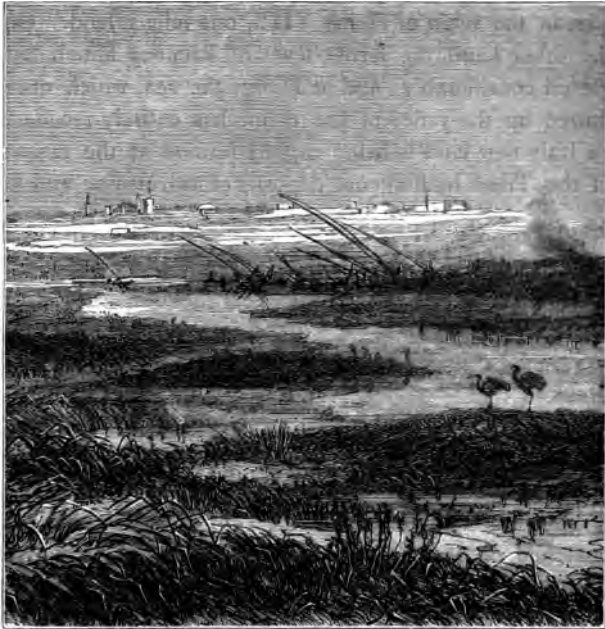
from the incessant "wear and tear" of the rocks that form its channel. This we may note for ourselves in almost every part of England or Scotland; in the neighbourhood of the Thames or the Trent, the Tay or the Dee. The Adige of Italy bears along with its waters such a mass of refuse, that it has entirely filled up its ancient outlets to the ocean, and is now compelled to disembody through new mouths. The Mississippi, in like manner, annually rolls down its turbid tide an immense amount of muddy deposit.

But when these materials cease to be carried onward by the moving waters, they necessarily sink to the bottom: the heaviest first; then the lighter pebbles, gravel, and sand; and, finally, the semi-liquid mud.

And so, in course of time, every lake is converted into a basin or receptacle for a series of stratified rocks produced by the streams which pour their waters into it.

In different parts of the lake these deposits will generally vary, for one stream will bring down one kind of material, and another stream another kind, according to the composition of the soil through which it makes its way; but in all cases the materials clearly show that they were produced, sifted, and deposited by the action of running water. It will be found that the finer marls and sands are arranged in layers or courses of varying thickness; that in the gravel-beds every stone will be smooth or rounded, like the wave-wrought pebbles of the sea-beach. Similar results are brought about by great rivers in their "deltas;" and lastly, the sea itself is incessantly preparing fresh stratified deposits by the force of its powerful continuous action. Is it not within the

personal knowledge of many of our readers that at some points of the coast-line the sea is making great inroads upon the land, and that the spoils it thus acquires it deposits at other points in the form of new stratified



DELTA OF THE NILE.

accumulations? It would be a grave error to suppose that Nature is at rest. The earth is incessantly undergoing changes of configuration, which necessitate corresponding changes in the relative position of the rock-deposits.

In the neighbourhood of the North Foreland—the promontory *Acantium* of the ancients, the Ἀκάντιον ἄκρον of Ptolemy—the chalk cliffs undergo an annual average waste of two feet. At Reculver, in the Isle of Thanet, the ruined church now tottering on the edge of the crag, was, in the reign of Henry VIII., one mile inland. On the other hand, the fertile level of Romney Marsh has gained considerably; and at Dover, the sea, which once flowed up the valley of the Dour, has entirely receded. In Italy new land is being rapidly formed at the mouth of the Tiber by immense deposits of travertine; and in



EROSIVE ACTION OF THE SEA.

historic times the shore of the Adriatic, from the south of Ravenna to the head of the Gulf of Trieste, has encroached on the sea to a breadth varying from two to twenty miles. The pine-woods between Ravenna and the Adriatic occupy an area of five miles, which was formerly a domain of waters:—

“ Ravenna’s immemorial wood,
Rooted where once the Adrian wave flowed o’er.”

The AQUEOUS ROCKS are generally arranged under two principal divisions, the *Mechanical* and the *Chemical*, according to the mode of their formation. The former are

those whose particles have been "mechanically" transported to their present position, and are sub-divisible into the *Arenaceous* or *Silicious Rocks*, such as sand and sand-stones, grits, breccias, and conglomerates generally; and into the *Argillaceous* or *Aluminous*, such as the marls, shales, clays, clay-slates, and flags or flag-stones.

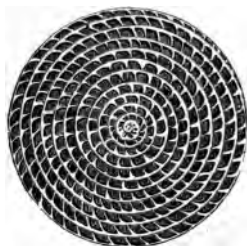
The "Chemical" rocks are those which have been



SECTION OF MEUDON CHALK.

created by chemical or vital agencies, and include the very important calcareous formations (chalk and limestone), as well as gypsum and coal. Chalk and limestone have originated in the deposit of the shells of foraminifera, molluscs, sea-urchins, sea-mosses, and other marine organisms. The nummulitic limestone, almost wholly composed of fossil nummulites, frequently attain a thickness of many thousand feet; and extends in Europe from

the Alps to the Carpathians, while in Northern Africa it may be traced from Egypt to Algeria.



NUMMULITE.

Gypsum, on the other hand, has been chemically compounded of sulphuric acid, lime, and water; while coal, as everybody knows, consists of vegetable matter solidified at a high temperature and under immense pressure.

We now return to our terrestrial habitation, with the view of pointing out the order in which its several stages, or “formations,” as the geologist calls them, are superimposed on one another.

Beginning with the most ancient, which are necessarily the *lowest*, and ascending towards the surface, we count the following principal sub-divisions :—

IN THE PRIMARY PERIOD.

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> <i>a.</i> Laurentian and Huronian. <i>b.</i> Cambrian. <i>c.</i> Silurian. <i>d.</i> Devonian (or Old Red Sandstone). | | <ul style="list-style-type: none"> <i>e.</i> Carboniferous. <i>f.</i> Permian (or New Red Sandstone). |
|--|--|---|

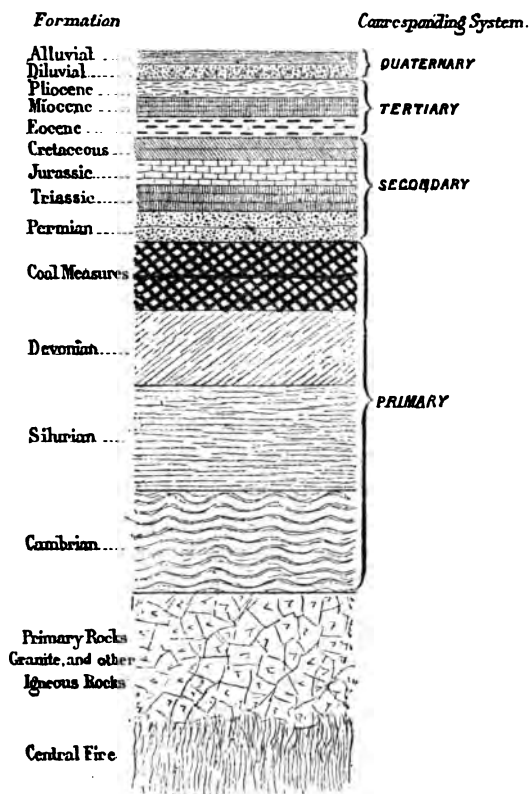
THE SECONDARY PERIOD.

- g.* Triassic (or New Red Sandstone).
- h.* Jurassic (or Oolitic).
- i.* Cretaceous.

THE TERTIARY PERIOD.

- | | | |
|---|--|---|
| <ul style="list-style-type: none"> <i>j.</i> Eocene. <i>k.</i> Miocene. | | <ul style="list-style-type: none"> <i>l.</i> Pliocene. <i>m.</i> Post-Pliocene. |
|---|--|---|

**Section of the Terrestrial Crust,
Showing the Different Formations from the
MOST RECENT TO THE MOST ANCIENT**



The first six of these "formations" are referred to the geological period known as *Primary* or *Palaeozoic*. The animals and plants which they preserve in a fossil condition, differ entirely from any now existing upon the globe.

The next three (*g, h, i*, Triassic, Jurassic, Cretaceous), belong to the Secondary or Mesozoic period; so called because its organic remains are intermediate (*μεσος* and *ζωη*) between those of the Palaeozoic period and those of more recent strata.

The last four (*j, k, l, m*, Eocene, Miocene, Pliocene, and Post-Pliocene), are grouped together under the head of *Tertiary* or *Kainozoic* (*καινος* and *ζωη*), because they are latest in point of time, their organic remains approaching very nearly in character to those now existing on the globe.

I. PRIMARY OR PALAEOZOIC PERIOD.

a. Laurentian.—The rocks of this formation are arranged in two sub groups, the Lower and Upper Laurentian. The former is wholly wanting in Great Britain, but is found in Canada with a total thickness of about 20,000 feet. It includes gneiss, mica-schist, quartzite, and limestones. The Upper Laurentian rocks (gneiss) are found in the Hebrides and the Isle of Skye.

Huronian.—This, too, is not a British formation. As its name implies, its rocks, which rest upon the Laurentian series, are found in the vicinity of Lake Huron and the other great inland seas of Canada. Total thickness, about 18,000 feet. They consist of quartzites, silicious strata, conglomerates, and limestones.

b. Cambrian.—The name “Cambrian” is derived from the fact that these strata are the lowest rocks visible in North Wales and its borders, the ancient *Cambria*.

In Great Britain the Lower Cambrian rocks are well seen in the Longmynd Hills of Shropshire, where they consist of about 25,000 feet of variously-coloured sandstones, grits, and shales, often rippled by waves that ebbed and flowed, and marked by rains that fell from cloudy skies, tens of thousands of years ago. These are succeeded by a great series of micaceous flagstones, slates, and shales, which vary in thickness from 2000 to 6000 feet, and belong to the Upper Cambrian age.

Cambrian rocks occur in other parts of Great Britain, and the following table will bring the reader acquainted with their principal members :—

(a.) *Lower Cambrian.*

1. Longmynd beds (25,000 feet).
2. Llanteris slates (3000 feet).
3. Harlech grits (6000 feet).
4. Oldhamia slates of Ireland.

(b.) *Upper Cambrian.*

5. Lingula flags of Wales.
6. Tremadoc slates of North Wales (2000 feet).
7. Skiddaw slates of the North of England (7000 feet).

The Cambrian beds are found also in Sweden, Norway, and Bohemia ; and in the State of New York, in North America.

c. Silurian.—This designation was suggested by the late eminent geologist, Sir Roderick Murchison, for a large series of strata lying underneath the Old Red Sand-

stone, and occupying those parts of Wales and England which, in the old historic times, were inhabited by the Silures, a tribe of ancient Britons.

The Silurian rocks are extensively distributed over Wales, Northern England, Scotland, Ireland; in Bohemia, Saxony, Sweden, and Russia; and in North America. The entire series may be subdivided into two groups, or sections, the Lower and Upper Silurian; and each of these is again subdivided into smaller sections, which take their names from the localities where they were first explored, or where they occur in full development.

Thus, in our own island, they are classified as follows, beginning with the lowest:—

- (a.) *Lower Llandeilo*: flags, slates, sandstones.
- (b.) *Upper Llandeilo*: micaceous flags, shales, grits.
- (c.) *Bala, Caradoc, or Coniston*: slates, grits, sandstones.
- (d.) *Lower Llandovery*: slates, sandstones, conglomerate.
- (e.) *Upper Llandovery*: limestones, shales, conglomerates, slates.
- (f.) *Wenlock*: shale, flag-stone, limestone.
- (g.) *Ludlow*: shale, limestone, sandstone.

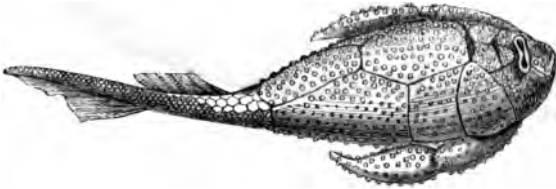
The first four groups belong to the Lower Silurian, and the last three to the Upper Silurian.

d. Devonian.—The Silurian rocks are succeeded, as we mount upward, by a very important and interesting system, to which the name of “Old Red Sandstone” was at one time applied. The strata belonging to this period are largely found in Devonshire, and hence they are frequently known as *Devonian*. But it is more than probable that, as Professor Nicholson suggests, the Devonian rocks represent a portion only of the Old Red

Sandstone, and are not to be regarded, therefore, as the full equivalent of that formation as it occurs in other regions. With this limitation, however, the term "Devonian" may be usefully employed as a general designation for those strata which intervene between the Silurian system and the great formation of the Coal Measures.

The Old Red Sandstone in Great Britain has formed the subject of a picturesque monograph by Hugh Miller. It is divisible into three groups, *Lower*, *Middle*, and *Upper Old Red*.

The *Lower* "Old Red" repose with admirable con-



FOSSIL FISH (PTERICHTHYS) OF THE OLD RED SANDSTONE.

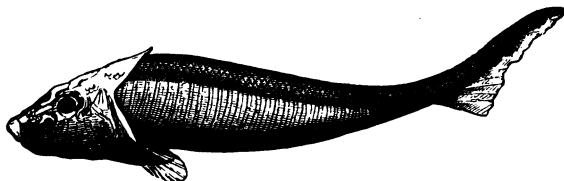
formity on the highest beds of the Upper Silurian, the two formations appearing to pass into one another by an intermediate series of so-called "passage-beds," which contain large specimens of the crustacean family of the *Eurypterida*. This section consists mainly of massive conglomerates, with sandstones, shales, and concretionary limestones. Its organic remains are almost exclusively confined to plants, crustaceans, and fishes.

In the *Middle* "Old Red" of Scotland we meet with dark gray flag-stones, bituminous flaggy shales, and conglomerates; not infrequently accompanied by shales in which irregular calcareous nodules are embedded. The

fossil remains are those of fishes, with a few plants and a solitary crustacean.

The *Upper* "Old Red" of Scotland consists of pebbly conglomerates, sandstones, and shales. Fossil fishes are abundant; there are several undoubted land-plants, and numerous fragments of supposed fuci and other sea-weed.

Underlying the carboniferous rocks, in Devonshire, is found a great series of strata, which has been regarded as the equivalent of the Old Red Sandstone. To this period, indeed, it unquestionably belongs, but yet it is



FOSSIL FISH (CEPHALASPIS) OF THE OLD RED SANDSTONE.

by no means apparent that the Devonian rocks can be regarded as the *equivalent* of the Old Red Sandstone of Scotland. They are largely represented, however, on the continent of Europe; and they are fossiliferous to a remarkable extent, though containing none of the characteristic crustaceans, and only one or two genuine representatives of the characteristic fishes of the Scotch Old Red.

The Devonian rocks of Devonshire consist essentially of greenish slates, alternating with sandstones, conglomerates, and well-developed bands of blue crystalline limestone and calcareous strata.

The Devonian strata are extensively developed in the United States of North America.

e. Carboniferous.—In this formation the workable coal-beds most commonly occur. They are found intercalated, in comparatively thin strata, between deposits of shales, sandstones, and limestones. In Great Britain, if we allow for the limited area, we must regard their development as unusually extensive. They are abundant also in Australia, North America, and on the continent of Europe. Generally, they may be divided into the following group, of which the first lies lowest :—

- (a.) The *Carboniferous Slates* and *Mountain Limestone*, which are mainly calcareous.
- (b.) The *Millstone Grit*, chiefly arenaceous and conglomeratic.
- (c.) The *Coal-Measures* proper, consisting of alternate shales, sandstones, and other strata, with workable beds of coal.

f. Permian.—These rocks, the uppermost of the Palaeozoic formations, are so named from the province of Perm, in Russia, where they abound, and where Sir Roderick Murchison investigated their nature. Formerly they were included, with the superimposed strata of the Trias, under the common name of New Red Sandstone; but this application of the term is now almost obsolete. They may be arranged under three divisions: the Lower, the Middle, and the Upper Permians; and are found in Russia, Germany, Britain, and North America.

g. Triassic.—The Triassic rocks form the base of the Mesozoic, or secondary series, and are identical with the upper beds of the New Red Sandstone of the earlier geologists. They are subdivisible into three groups: the Lower, corresponding to the Bunter Sandstein (or “varie-

gated sandstone") of the Germans, and consisting of red and white sandstones, red clays, and thin limestones, with a total thickness of about 1500 feet; the Middle, or Muschelkalk ("mussel limestone") of Germany, consisting of compact gray or yellowish limestones, with beds of rock-salt and gypsum; and the Upper or Keuper ("copper"), consisting of white sandstones, brown sandstones, red marls, red clays, rock-salt, and gypsum. The Middle Trias is not found in Great Britain.

h. Jurassic.—The rocks included in this group are sometimes termed Oolitic, because they generally contain oolitic limestones, or limestones made up of granulated particles, oval, like eggs (Gk. *ovon* and *λιθος*); and sometimes Jurassic, because they are extensively developed in the noble mountain-range of the Jura, on the western borders of Switzerland. They occupy a considerable area in Great Britain, where their component parts are generally found in the following order:—

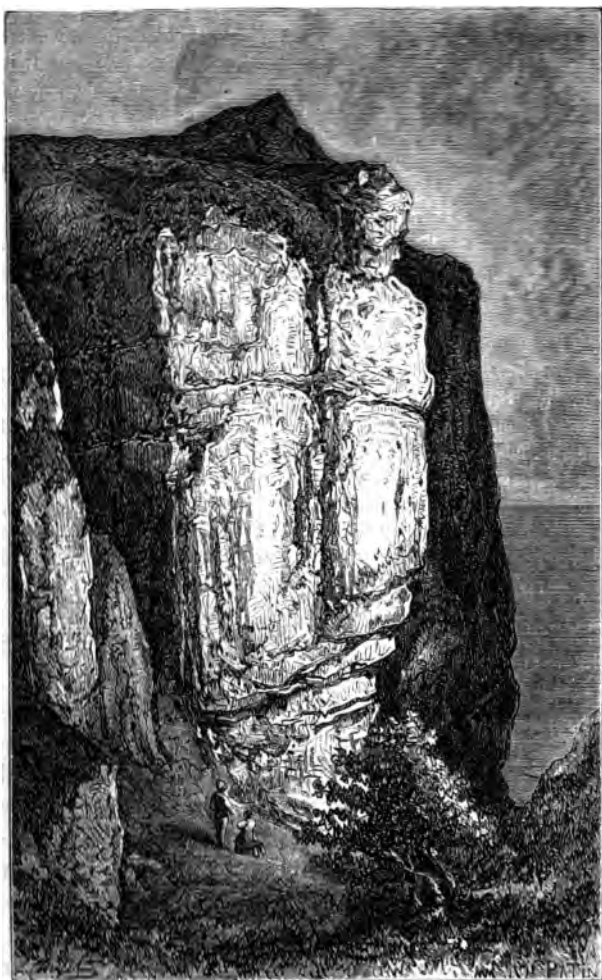
- (a.) *Lias.*
- (b.) *Lower Oolites*: consisting of the inferior oolites, fuller's earth, great oolite, Stonesfield slate.
- (c.) *Middle Oolites*: Oxford clay and coral rag; and
- (d.) *Upper Oolites*, or Kimmeridge clay, Portland stone, and Purbeck beds.

i. Cretaceous.—This formation derives its name from the prevalence of chalk (*creta*) among its principal rocks. It is well known in the south and south-east of England, from Portland Bill to the North Foreland. The usual arrangement is as follows:—

- (a.) *Wealden*: so named after the Weald (*wold*, or forest wilderness), a part of Surrey, Kent, and Sussex, where it is spread over a very considerable area. A characteristic of this district is its undulating ranges of chalky downs, covered with crisp and fragrant turf, and sheltering in their recesses the most picturesque *combes* or hollows. Springs are abundant.
- (b.) *Lower Greensand*, or *Neocomian*: the latter term derived, for a similar reason, from Neufchâtel (Lat. *Neocomum*), a town in Switzerland. These groups, *a* and *b*, form the *Lower Cretaceous*.
- (c.) *Gault* (from a provincial term).
- (d.) *Upper Greensand*.
- (e.) *Chalk proper*: which may be traced from the north of Ireland to the Crimea, and, in an opposite direction, from the south of Sweden to Bordeaux, or 1140 by 840 geographical miles. With or without flints, it occupies a considerable area of south-east England, rising on the sea-coast into lofty cliffs of a romantic configuration. When flints occur, they are generally disposed in their layers at some distance apart; so that a chalk cliff, from a distance, seems scored with horizontal black lines, as if they had been mechanically ruled.
- (f.) *Maestricht beds*: a series of yellowish limestones, about one hundred feet in thickness.

We may add, with respect to the Wealden, that, geologically, it is of the highest interest, being undoubtedly the delta of a mighty primeval river which flowed from an ancient continent on the present site of the Atlantic Ocean. It is composed almost wholly of fresh-water beds, diversified, in the lower portion, by a few brackish-water and even marine strata.

j. Eocene.—We now come to the Tertiary or Kainozoic series of beds. And here it must be noted, at the outset,



CHALK CLIFFS IN THE ISLE OF WIGHT.

that a singular but complete gap occurs between the rocks of the Mesozoic and Kainozoic periods ; a gap representing some immense but wholly indefinable interval of time.

The division of the Tertiary formations into " Eocene," " Miocene," " Pliocene," and " Post-Pliocene," is due to Sir Charles Lyell, who based it upon the proportion of living or existing species of molluscs occurring in each stratum or group of strata. The terms are compounded from Greek words, and signify, literally, " Earliest New" ($\epsilon\omicron\varsigma\text{-}\kappa\alpha\iota\nu\omicron\varsigma$), " Less New" ($\mu\epsilon\iota\omicron\nu\text{-}\kappa\alpha\iota\nu\omicron\varsigma$), " More New" ($\pi\lambda\epsilon\iota\omicron\nu\text{-}\kappa\alpha\iota\nu\omicron\varsigma$), and " After More New" (*post*, and $\pi\lambda\epsilon\iota\omicron\nu\text{-}\kappa\alpha\iota\nu\omicron\varsigma$).

Of these, the Eocene formation, as its name indicates, is the oldest, and contains the smallest proportion of existing species. It is found in Great Britain, France, the Netherlands, the Alps, and North America ; and is subdivided into—

- (a.) *Upper Eocene* : identical with the French gypsum of Montmartre, calcaire silicieux, grès de Beauchamp, or sables moyens.
- (b.) *Middle Eocene* : identical with the French calcaire grossier, Soissonais sands, or lits coquilliers.
- (c.) *Lower Eocene* : identical with the French argile de Londres (or London clay), argile plastique, and lignite sables de Brecheux.

k. The *Miocene* formations are divisible into Lower and Upper. The latter includes the " Faluns" of France, and the " Molassi" (a soft greenish sandstone) of Switzerland.

l. In Great Britain the *Pliocene* deposits occur in Suffolk,

where they are known as "Craggs;" "White" and "Red Craggs" belonging to the Older, and "Norwich Crag" to the Newer Pliocene.

Elsewhere, the principal Pliocene beds are found in the neighbourhood of Antwerp, in the sub-Appennine chain of Italy, in the upper valley of the Arno, in Sicily, in the Aralo-Caspian basin, and in the American States of North and South Carolina.

m. Post-Pliocene.—The deposits of the Post-Pliocene, or Quaternary period, may be divided into those which preceded the great Glacial Epoch, when vast rivers of ice traversed, as upon guiding wheels, the valleys, plains, and mountain declivities of Europe and North America; those deposited during this age of desolation and darkness, and those which followed it: or, in other words, into Pre-Glacial, Glacial, and Post-Glacial.

In our own island the principal Pre-Glacial deposit is found on the Norfolk coast, where it is termed the "Cromer Forest-beds." The Glacial deposits are more numerous, and consist of boulder-clay (or till), stratified drift, and drift-gravels. The Post-Glacial are all fluvial, such as gravels and brick-earths, with the exception of the accumulations found principally in caves, and termed "cave-deposits" and "ossiferous breccias."

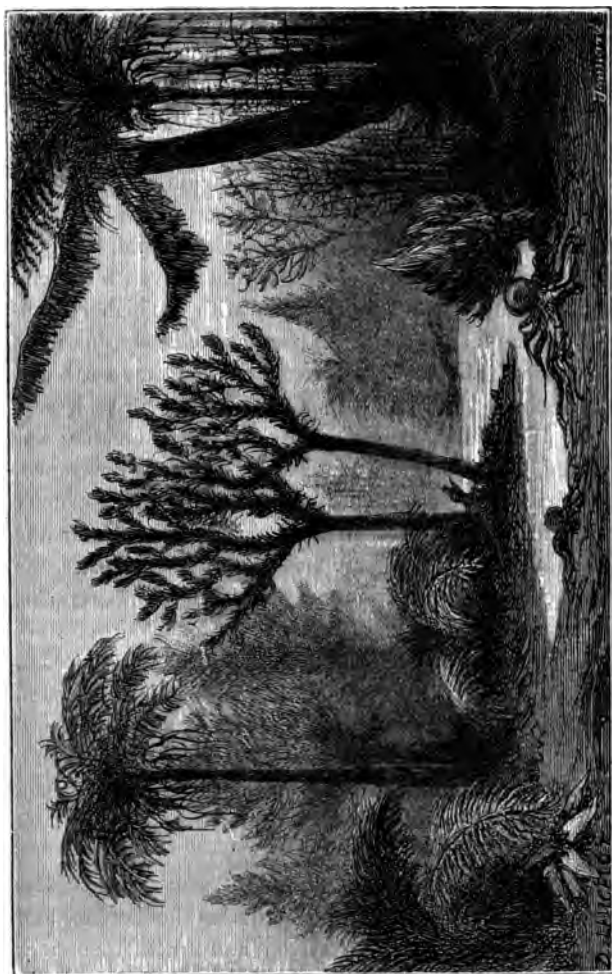
We have thus brought before the reader, in due order, the various formations which build up the terrestrial crust. He has seen that they lie superimposed upon one another, like the leaves of a book, though more irregularly. And do they not represent to us a grand, a

glorious book, the Revelation of Nature ; a book which will demand and repay our most laborious and intelligent study ; a book in which, with a Divine hand, the marvellous story of the creation of a world has been graphically written !

It would appear that life dawned upon earth contemporaneously with the deposit of the earliest sedimentary rocks. The lowest forms of the plant-world, and the first animal organisms, perfect in themselves, but seemingly rudimentary when compared with the higher mammals, came into existence as soon as the atmosphere was in a condition for them to respire it, and the earth and water could supply the aliment necessary for their support. Gradually, as the mighty scheme of creation was educed, life became more fully and more freely developed, and fresh species, each displaying some novel ingenuity of structure, appeared in swift succession. After the foraminifera came the molluscs ; after the molluscs, the crustaceans ; and then, in meet gradation, fishes, reptiles, birds, mammals, man.

In like manner, the humbler plants, the delicate mosses, the parasitic lichens, and the simple fucoid forms, soon saw springing up around and above them the rich and varied ferns, whose arborescent species, in the Carboniferous period, attained a development surpassing even that which they now exhibit in tropical regions, and more particularly in New Zealand.

To the ferns and their congeners were joined, after awhile, the conifers ; and finally, during the Tertiary and Post-Pliocene ages, those sylvan and fructiferous trees and plants which refresh us with fruit and shade, or sup-



LANDSCAPE OF THE CARBONIFEROUS PERIOD.

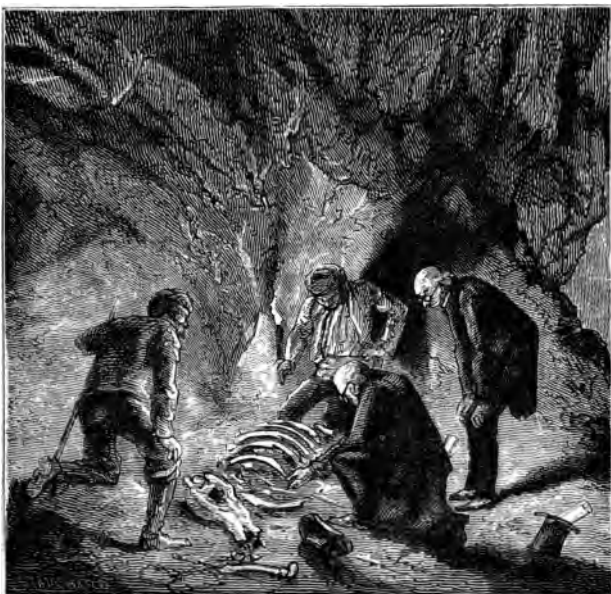
ply us with useful and ornamental timber, at the present day.

The remains of these living bodies, these wonderful vital forms, which from the earliest terrestrial ages have successively taken their places in the perfect economy of nature—the remains of these "created things," either their outer case or sheath, their internal framework or skeleton, or their faint impressions in the different strata composing the sedimentary rocks—are the so-called "fossils" of geologists, and the "petrifications" of the unscientific. For the latter speak of petrified plants, petrified shells, petrified bones, and so on; and their language, though inexact, is impressive.

Fossils, as the reader will suppose, have always formed a favourite subject of discussion among the disciples of science. By some authorities they were formerly accepted as an incontestable proof of the occurrence of the Noachian Deluge; while others refused to see in them anything more than the scallop-shells and relics lost by pilgrims returning from the Holy Land, or the residuum of the cabinets of naturalists thrown aside as worthless! This absurd hypothesis was actually put forward by Voltaire and the Encyclopédistes.

Wiser now, we accept the fossils at their exact value, as, to adopt a felicitous phrase, the "medals of creation." With their assistance, with the help of these wonderful hieroglyphs which were so long considered undecipherable, the geologist reconstructs the primeval earth; just as by the aid of ancient coins and palimpsests the historian revives the nations and societies of an era which has passed away.

Fossiliferous deposits are found in every country. Some of the highest interest and importance have been discovered in France, England, Germany, Italy, and the United States. In the last century, on the banks of the Maes, the famous quarries of Maestricht attracted the



BONE-CAVERN OF MAESTRICHT.

attention of the scientific. During the early days of the French Revolution, the republican government of France directed its attention to these caverns, and commissioned a naturalist, M. Faujas de Saint-Fond, to examine and report upon the fossils they contained. Those were

times in which men went to the front willingly both in war and science. Faujas carefully explored the interior labyrinth of the mountain of St. Pierre, without arriving at a correct conception of the nature of its fossil treasures; and it was left to Cuvier to demonstrate that they formed the remains of an immense extinct reptile, which he named the "*Mosasaurus*," or Saurian of the Maes (Lat. *Mosa*). Thus ended the story of the "*Great Animal*" or



SKULL OF MOSASAURUS.

"*Great Crocodile*" of Maestricht, which for many years engaged the speculation and excited the curiosity of naturalists.

The theories put forward by scientific men on this subject are matched in extravagance by the notions current among the common people. These at different times have varied greatly, and hence our fossils have been described as "*freaks of nature*," the effects of the planetary influences, the productions of celestial thunderbolts, and the like. The Germans, in more poetic mood, imagined them to be the work of the genii of the underground world, Nickel and Kobolt; who, burrowing mole-like in the fossiliferous localities, digging lustily beneath the surface, and piling rock upon rock, Pelion upon Ossa, and Ossa upon Olympus, covered them with those strange, fantastic, and mysterious designs, the fossils.



THE GENII OF THE UNDERGROUND WORLD.

We have pointed out that, as the different formations were successively accumulated, life underwent a succession of modifications: the animal world, for example,

constantly developing higher and more complex types of organization. We have shown, too, that last of all came man: *last*,—upon so much are all geologists agreed; but *when*? is a question they have by no means harmoniously settled. Was he contemporaneous with the most recent alluvial deposits, or did he precede them? Was he or was he not brought upon the scene at the same time as the great Post-Tertiary mammals, the Irish elk, the woolly rhinoceros, the mammoth? In a word, is he or is he not a Fossil?

We venture to think that the question is closely connected with the subject of the present volume, and that, therefore, the reader will permit us to devote a few pages to its consideration. It is one of the most interesting topics which a study of the world "beneath the surface" can suggest.

Only, it is necessary the reader should remember that we concern ourselves simply and exclusively with *Fossil Man*. The paleontologist, as a recent writer remarks, has no concern with other than human remains of the Post-Pliocene period. So far as they are associated with those of species of mammals still in existence, they do not come within our province. *Savage Man* is a subject for the consideration of the ethnologist or philosopher; and it is to the conditions of life of *Prehistoric* or *Fossil Man* that we propose to direct our attention.

CHAPTER II.

PREHISTORIC MAN.

A definition of "Fossil Man"—The earth an extinct sun, on which the waters have built up continents, and life has undergone various evolutions—Fossil Man and Prehistoric Man considered—Researches of the earlier geologists—Curious error as to the "homo diluvii testis"—The Anthropolithes—Opinion of Cuvier—The Bone-caves and their treasures—Objections and objectors—M. Boucher de Perthes—Stone-hatchets of the valley of the Somme—The celebrated "jaw" discovered at Moulin-Quignon—A Scientific Congress—Yol—Menchecourt—Fabricators of flint-weapons—The miller Quignon—Discoveries of M. Lartet—Discoveries in Belgium, England, Germany, Italy, and America—Inferences deducible from well-authenticated facts.



It is desirable, at the outset, that we should define with some degree of exactness the problem we are about to examine.

We shall refer, then, to Primeval Man, such as modern science describes him, such as recent discoveries enable us to picture him. Fossil Man is primeval man, extinct man, so far as geology is concerned, who has left in the subterranean strata of the globe the imprint of his petrified bones, and even the traces of his remote industry.

Fossil Man : that is, man dating back far beyond the earliest records of history ; back beyond even those of mythology ; dating back into the shadow and obscurity of the geological period. Was ever a more interesting

subject submitted to the speculations and inquiries of the philosopher?

The difficulty is, to fix the precise epoch when, in the course of life's incessant evolutions, man in his turn appeared upon the terrestrial scene, a new link in the chain of living forms, or rather the link which completed the mighty chain. The reader cannot fail to perceive how largely both ethnology and history must gain by the well-directed study of this phenomenon.

The old story runs that Socrates wrote upon the walls of his *schola*, or lecture-room, the celebrated aphorism, which he never wearied of repeating to his disciples: *γνῶθι σεαυτόν*, "Know thyself." In the present case it is well that we should adopt, at least in its physical sense, the wise maxim of the Greek philosopher. Let us investigate the origin of our race, and by so doing learn to know ourselves more thoroughly, and to define exactly the place occupied by Man in the great scheme of the universe.

Whether we take up the view of Laplace that the earth was a nebula thrown off or evolved from the great solar luminary, or whether we agree with some modern philosophers that it was a portion of cosmic matter suddenly condensed into a spheroid, our planet, briefly speaking, is neither more nor less, perhaps, than an extinct sun. Such, at least, was the hypothesis of Cuvier; and it is not to be derided because it was adopted by a poet:—

"Strange was the infancy of this our world,
As Buffon said and Cuvier has proved:
A spark of fire within a sphere of mud
Gave birth to the compact harmonious orb."—BERANGER.

But whatever the process by which our planet attained proportion, it is certain that the waters, by the gradual deposit of argillaceous and calcareous sediment, built up the continental masses. And the organic forms which lived within these waters, upon their surface or their shores, have been, as we know, successively engulfed in the strata thus developed. It is the remains of the extinct forms, deeply embedded in the heart of the sedimentary rocks, which constitute our so-called "fossils."

And it is their peculiar characteristic that they generally belong to extinct species, and to species more and more highly organized as we ascend the scale of formation into which the terrestrial crust is divided. In the Primary period, crustaceans of enormous size appeared, the ancestors of our crabs and lobsters, as well as the earlier fishes; to the Secondary belonged gigantic saurians, the precursors of the lizards, serpents, and reptiles of to-day; to the Tertiary, the great mammals, the ancestors of our elephants, tapirs, and rhinoceroses; and in the Quaternary, along with the *Elephas primigenius*, Man appeared.

But has he left any traces of himself in the earlier deposits of that Quaternary period, the "gravel beds" and "regenerated drifts," as they are called—any traces commingled with those of the large mammals? Or was his appearance deferred until towards the end of that period?

These are the points which invite discussion. If man is "fossil," his antiquity must be vast; must be calculated by tens of thousands of years. If he is *not* "fossil,"

he will have come upon the terrestrial stage comparatively recently ; it may be six or seven thousand years

SCENE DURING THE REINDEER EPOCH.



ago. But Fossil Man, or the being we so distinguish on account of the analogy or even identity of his organiza-

tion with our own, Fossil Man is brought plainly before us by his indisputable memorials; and one of the most interesting discoveries of modern science is the contemporaneity of man with the great extinct mammals: such as the cave-bear, the cave-hyæna, the *Rhinoceros ticorninus*, the mammoth, the cervus megaceros, and the reindeer; one species of the last-named having then inhabited Temperate and Southern Europe. I do not speak of the aurochs, the urus, or the musk-sheep, because these are either living amongst us still, or have only recently disappeared.

The discovery of Fossil Man is closely connected with the discovery of what we may call Ante-Historic or Mythological Man, who is celebrated in the legends of every nation, and who has been rehabilitated by our scientific investigators; I mean, the Man of the peat-bogs, the lake-villages, and the Danish "kitchen-middens," *kikkemoeddings*. But I must confine myself to Fossil Man properly so termed, the eldest-born of our race; to Fossil Man as revealed to us by a careful study of the relics and memorials which lie "beneath the surface."

The most important facts ascertained in reference to the early condition of man have been succinctly summarized by Professor Nicholson, and thrown into the shape of propositions, six in number.*

1. Man, he says, unquestionably existed during the later portion of what Sir Charles Lyell has called the "Post-Pliocene" period. In other words, man's existence dates back to a time when several remarkable mammals had not yet become extinct; but he

* Nicholson, "Manual of Paleontology."

does *not* date back to a time anterior to the present molluscan fauna.

2. The antiquity of the so-termed Post-Pliocene period is a matter which must be mainly settled by the evidence of geology.

3. The extinct mammals with which man was contemporary in Western Europe are mostly of large size—the most important being the mammoth, *Elephas primigenius*; the woolly rhinoceros, *Rhinoceros tiorhinus*; and the cave-lion, *Felis spelæa*. The causes which



MAMMOTH—RESTORED.

led to the extinction of these Post-Pliocene mammals are unknown; but it is certain that no mammalian species has died out during the historical age.

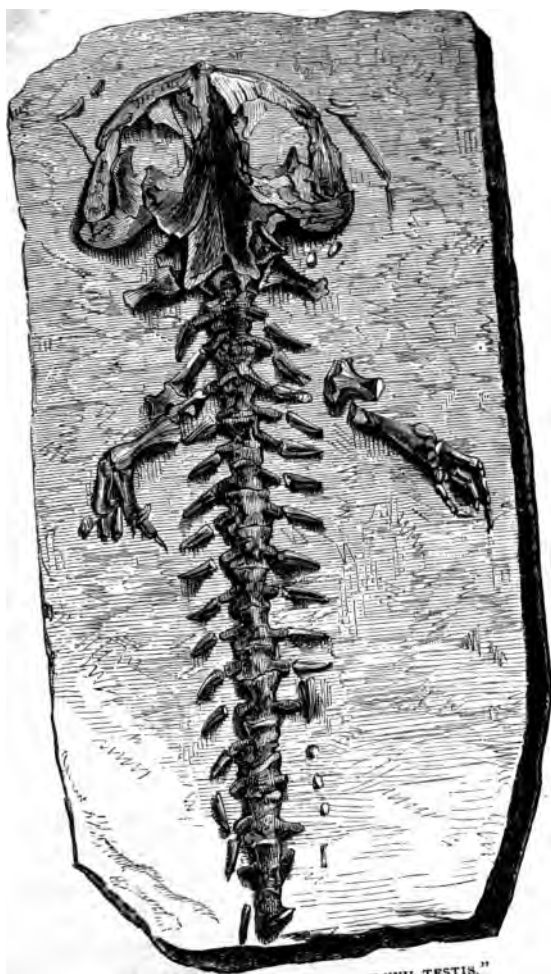
4. The extinct mammals contemporaneous with man are referable, in many cases, to species which must be supposed to have required a climate differing greatly from that now prevailing in Western Europe. How long an interval, however, has been occupied in accomplishing the climatic changes thus indicated, science is unable to determine with any approach to accuracy.

5. It is clear, from some of the deposits in which the remains of man have been found associated with the bones of extinct mammals, that great changes in the physical geography and surface configuration of Western Europe have occurred since the epoch of their accumulation. But we have no means of calculating the lapse of time that must necessarily have taken place, except by analogies and comparisons which are not infallible.

6. The human implements associated with the remains of extinct mammals bear witness in themselves to the exceedingly barbarous condition of the human species. Post-Pliocene or paleolithic man was clearly unacquainted with the use of any of the metals. Not only so, but the workmanship of these ancient races was much inferior to that of the later tribes, who were also ignorant of the metals, and used only weapons and tools of stone.

Fossil Man is a subject which has long proved irresistibly attractive to the scientific inquirer. The strange and apparently nondescript creature which the elder geologists christened the "man of the Deluge" (*homo diluvii testis*), was the one all-convincing testimony they brought forward in support of their theories. While they erred on the side of credulity, many of our modern students would seem to err on the side of scepticism, since they persist in discrediting the undoubted discovery of "Fossil Man." So strange are the oscillations of opinion, which varies from one side to the other of the direct road of truth, and seems utterly unable to preserve the "golden mean."

Still, there can be no doubt that the problem has made considerable progress towards a satisfactory solution, and that light is breaking in upon the darkness. Throughout the whole course of the present century, in the bone-caves and in the strata of those Quaternary deposits known as "Diluvial," an army of industrious explorers have laboured



THE SUPPOSED "HOMO DILUVII TESTIS."

perseveringly and intelligently, and have been rewarded by the discovery of weapons and implements of stone, as well as human relics, mingled with the remains of extinct species of mammals.

We have spoken of the supposed *homo diluvii testis*. An individual thus romantically designated was ascertained by Cuvier to be in reality a batrachian, an enormous frog ; another, the skeleton of a negro which had become embedded in the coral masses of a distant shore. As for the petrified bones formerly hawked through the Continental cities, as those of Teutobocchus, a gigantic king of the Cimbri conquered by Marius, they proved to be the remains of a mastodon.

We need do no more than refer to the pretended discoveries which have arisen out of a spirit of mystification, like that of the "man of stone" found in the forest of Fontainebleau, "some sixty years since," which related its own supposititious history in a *brochure* now very seldom met with. This "petrified man" was nothing more than a block of sandstone of curious shape, like many others which are to be found in the forest. I am reminded of another imposition ; a man of the age of the Peruvian Incas, of a gingerbread colour, "discovered" a few years ago in the guano deposit of the Chincha Islands, brought to Europe, and exhibited at every fair. But I will dwell no longer on these ludicrous hoaxes, which could bewilder only the credulous or ignorant. Let us return to the genuine remains of Primeval Man, whose existence is no longer a matter of speculation.

The French naturalist Cuvier asserts that, down to

his date, science had not succeeded in establishing the existence either of a "fossil age" or of "fossil man;" and he suggests that probably the continents where the "gray forefathers of the world" had lived, along with their immediate neighbours in the animal scale, had been engulfed under the waters in some geological cataclysm.

Shortly afterwards, discoveries were made in the bone-caves of skulls of singular conformation, resembling rather the cranium of the ape than that of man, and always associated with a variety of bones, tools fashioned out of stone, and axes manufactured of flint.

Immediately there stepped forward a number of adventurous theorists, affirming that these were no other than the remains of Primeval Man; that the conditions of their discovery incontestably demonstrated his contemporaneity with the great extinct mammals; and that, consequently, the first appearance of humanity upon earth must be relegated far beyond the earliest epoch hitherto acknowledged by chronologists.

At Engis on the Meuse, at Neanderthal in Bavaria, in the south of France, at Bizes, in the department of Hérault, the bone-caves have yielded to the research of the industrious the bones of bears and hyænas, besides fragments of rudely-wrought pottery, and other memorials of the primeval world. But it is urged, as an objection to their antiquity, that caves have at all times served as asylums for animals and man, but that the men whom it is sought to trace back to so remote a past really inhabited these recesses long after the age of the Tertiary mammalia. There he made his dwelling-place, and there he buried his dead. It was in this way his bones came

to be mingled with the fossils of the primeval animals. As for the marks and indentations of the bones, they were made by the molars and incisors of beasts of prey !

That the accumulation is heterogeneous, the objectors admit ; that it consists of memorials of ancient industry and bones of extinct animals ; but then the waters must frequently have inundated these caverns, and disturbed their contents.

Further, in reference to the caves of the Pyrenees and the Cevennes, the incredulous cite the Religious Wars and *Dragonnades* as having driven the persecuted peasants to seek shelter in the mountain valleys ; forgetting that within the last two or three centuries man has not fought with swords of flint, with barbed arrow-heads of bone, or prepared his food in vessels of unbaked clay.

This theory, however, of the recent occupation of the bone-caves obtained very general acceptance ; and, in 1847, one of the ablest of the French physicists wrote an article in its support in D'Orbigny's great " Dictionary of Natural History," which immediately took rank as a classic authority irrevocably deciding the question.

M. Desnoyers, notwithstanding, has since recanted, and adopted the " new views." Now-a-days he is as far in advance of the partisans of Fossil Man as formerly he was behind them. But, not to anticipate events, I shall attempt a brief survey of the transitional period through which our philosophers have passed, both in England and France, in their advance from one extreme to the other, or, let us rather say, from error and speculation to inquiry and truth.

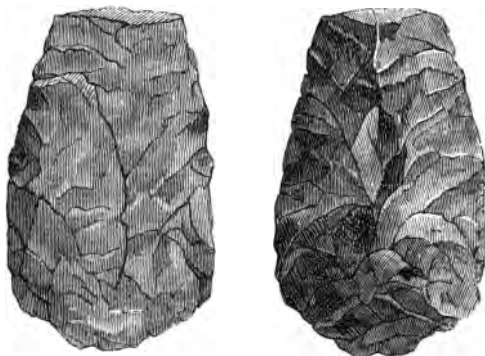
The merit of having decided the points at dispute would seem to belong to France. The earliest and not the least important facts were collected and put into shape by two French explorers. One, an eminent and persevering archæologist, M. Boucher de Perthes, is recently dead ; the other is the well-known paleontologist, M. Lartet, whose learned and valuable "*Reliquiæ Aquitanicæ*," are in course of publication in England.

To each of these Christopher Columbuses of paleontological science, I shall seek to ascribe the merit which is justly his share.

M. Boucher de Perthes, though his discoveries have been the last to receive the stamp of authenticity, deserves to be first named, because the first in point of time. His researches began very early in the present century. With simple faith he wandered to and fro in quest of traces of the children of Adam and the Noachian deluge. In the caverns east of Marseilles, at Genoa, afterwards at Pecq, near Saint-Germain, and in the Champ de Mars of Paris, he exhumed from the diluvial drift numerous stone weapons of the rudest design, evidently the remains of man's primeval industry. But his most remarkable discoveries, and those which mainly excited the curiosity of the scientific world, were made at Moulin-Quignon, near Abbeville, and at Saint-Acheul, near Amiens. At Moulin-Quignon exists a diluvial bed of pebbles, and rolled and agglomerated flints, intercalated with strata of a red clayey earth. Similar deposits are scattered in the vicinity of Abbeville, and have been quarried from time immemorial for the purpose of repairing the neighbouring roads.

M. Boucher de Perthes had again and again remarked among these pebbles some curiously shaped fragments, roughly triangulated, and bevelled at the edges, which presented evident signs of having been manipulated by human industry. They reminded him of the *celts*, or polished hatchets, used by the Celtic tribes and their ancestors.

In 1847, having collected a large number of these memorials, he communicated the result of his explorations



FLINT AXE-HEADS.

to the Academy of Sciences at Paris, and invited its members to visit and examine his cabinet. As frequently happens in such cases, his communication was regarded with much suspicion ; and more than one physicist expressed their belief that M. Boucher de Perthes was a monomaniac.

M. Boucher, however, was nothing of the kind, but an obstinate Breton, who, throughout his life, continued to plead the same cause, and to plead it so ably, so perse-

veringly, and with such complete indifference to satire or ridicule, that he eventually proved successful. He may, perhaps, be justly designated the true sponsor of Fossil Man ; and his is the honour of having been the first to define the "age of stone," and to procure its final acceptance on the part of the scientific world.

Among M. Boucher's discoveries, however, we must admit that one has been to this day the mark of hostile criticism ; the Fossil Jaw of Moulin-Quignon, which formerly created so loud a tumult in the serene halls of science.

Objection had been frequently taken to the fact that M. Boucher de Perthes found numerous—in fact, any number of—hatchets, but no human bones ; and consequently, it was urged, the deposits in which he made his researches could not be deposits formed *in situ*, but only shifting, variable, irregular deposits. In a word, he was confronted by the same scepticism which had attacked the bone-caves. M. Boucher de Perthes replied, that not only was each deposit a deposit formed *in situ*, but that he believed the localities where he found his axes had been the localities of the very factories in which these axes had been wrought. He expressed his strong and earnest hope that, some day or other, he might succeed in disinterring one of the old antediluvian flint-weapon manufacturers ; in a word, a genuine fossil man. Accident fulfilled his desire. In 1862, one of the quarrymen at Moulin-Quignon informed him that, in a section of the quarry, had been found a human jaw, well supplied with teeth. M. Boucher de Perthes hastened to the spot. In the presence of witnesses the jaw was carefully exhumed :

it proved to be a lower jaw, in which several teeth were still implanted. Immediately a congress of naturalists, geologists, and archæologists assembled from all parts of Great Britain, France, and Germany. As amongst us the question of the antiquity of man has always involved the necessity of reconciling scientific deductions with scriptural traditions, the most lively curiosity was exhibited by our scientific inquirers, who kept the telegraph in constant operation while the precious jaw was being examined with the most rigid accuracy. All who were present offered their opinions or advanced their objections; but at length the majority pronounced their verdict that the jaw of Moulin-Quignon was that of an antediluvian man.

The news of this great discovery reached Paris. The scientific societies bestowed their honours on some of the members of the Abbeville congress; on M. Boucher de Perthes, and on M. de Quatrefages, in honour of the victory which, as they conceived, had crowned the enterprise of French science.

The jaw, purchased by M. Boucher de Perthes for a considerable sum, and by him presented to the Museum of Paris, is now deposited in the collection of the Anthropological Society. There it stands, mounted on a pivot of brass, and carefully covered with a glass globe, that the curious may examine but not touch. It has been sawn through the centre, so as to expose a section of the interior. This has originated doubts on the part of many geologists and chemists, who assert that if it were analyzed traces would still be found in it of gelatine; a

proof that it is comparatively recent. Others object that not only is the drift-bed of Moulin-Quignon of a peculiarly shifting character, but that in times of plague it has been used as a place of interment,—that is, in the sixteenth and seventeenth centuries,—and that, consequently, the human remains discovered in it belong to this period, and are easily accounted for.

Such would seem to be the opinion of our most trustworthy English authorities ; but the French anthropologists, with M. Pruner-Bey at their head, have committed themselves to a defence of the antiquity of the jaw, to which they attribute certain anatomical peculiarities.

Had the remains of the owner of the jaw been discovered, much difficulty would have been obviated. Spiritualists have consulted their mediums on this all-important point, and enchanted tables have “rapped out” as an answer that the fossil man of Moulin-Quignon was named Yoah (perhaps they meant Noah ?), and that his remains would be found if the explorers measured out ten feet eastward from the point where the jaw was disinterred. Well, they measured, and measured, but with no result. The spirits have been proved as ignorant as men of science !

At Menchecourt, near Moulin-Quignon, and at Saint-Acheul, near Amiens, several flint hatchets have been excavated ; and this, not in any doubtful deposit, but in the midst of stratified sandstones, and above the level of the highest waters of the Somme.

In the sands occur the fossilized bones of the elephant, stag, reindeer, primeval horse, so that the coexistence

of man and of these extinct animals can no longer be doubted, the sandy strata lying *above* the deposits of wrought flint.

Not only has the authenticity of the jaw found at Moulin-Quignon been questioned, but also that of the flint implements; on the ground that numbers of forged specimens have been manufactured for the purpose of being sold to tourists. We have read of a merchant at Abbeville, who sold his imitation antiquities both at Moulin-Quignon and Saint-Acheul. Moulin-Quignon exhibits a superficial deposit of reddish or blackish sand; Saint-Acheul, of grayish sand. The relic-vendor coated his hatchets with an adhesive substance, and then plunged them into a chest filled with sand from one or the other locality, according as his correspondents wrote from Moulin-Quignon or Saint-Acheul. In Italy bronzes and antique medals are got up in a similar manner, and are properly coloured and oxidized by being buried in the ground. But if there are forged medals and sham statues, there are also *true*; and the same is the case with the flint hatchets. Because some of the articles obtained from the localities named have been fictitious, are we justified in denying the genuineness of all?

As for Quignon the miller, who has given the name of his mill to this famous spot, he does not appear, says a recent writer, to suspect the existence of "Fossil Man," or to estimate properly the tremendous effect which the words *Moulin-Quignon* produce among a group of anthropologists. All the stir took place within a few yards of his residence, and he knew nothing or cared nothing about it. The mill, equipped with a couple of gigantic sails, is

planted on a hillock, and there its owner lives a life of inglorious contentment :—

The well-known mill its well-known owner's name
Triumphant bears, for honest he and just,
And great his fame through all the country-side ;
And to whatever airt the light breeze blows,
He turns his sails, and then contented sleeps.

We have now to speak of the labours of M. Lartet.

He has everywhere established beyond doubt the pres-

ence of Primeval Man, and notably so in the caverns of Périgord, with the Post-Pliocene animals, such as the mammoth, reindeer, aurochs. In the midst of the bones of these fossil animals, and incrustated in the sediments of the caverns, he has found all kinds of remains of man's primitive industry, both tools and weapons : axes, arrow-heads, and spear-heads, knives, bodkins, graters ; also, vessels of baked and unbaked clay, fire-scathed stones, bones fashioned as needles, arrow-points, dagger-handles, and the like. And, finally,—the last and most convincing discovery,—he had the good fortune to alight upon a

FLINT KNIFE
FROM PERIGORD.

plate of ivory, either mammoth's or the primeval elephant's, on which the figure of a mammoth was drawn with so much accuracy that the representation could not be mistaken. Primitive Man

FLINT SCRAPER
FROM PERIGORD.

himself had drawn the animal which bulked so formidably before his eyes. M. Lartet had previously detected rude designs upon bones of kids, and reindeer, and horses; but who would continue to doubt after he had discovered a drawing of a mammoth figured on a tablet of the ivory yielded by the mammoth himself?

Observe, it was in 1865 that this last and most important discovery was made.



ENGRAVING OF MAMMOTH ON IVORY PLATE.

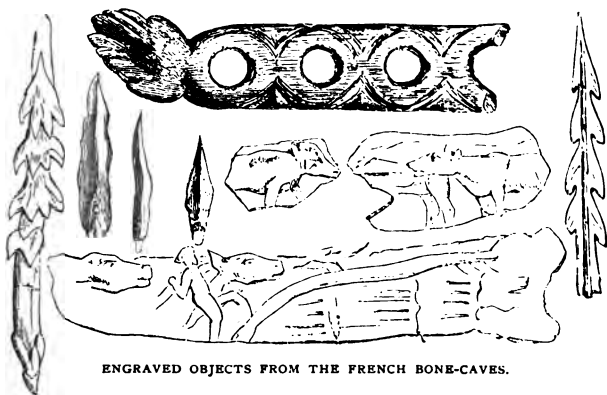
It has since been corroborated by other "treasures;" and indefatigable explorers have brought together evidence which cannot be disputed of the existence of primeval man.

M. de Vibrayé has found, in the caverns of Central France, the jaws and skulls of antediluvian men.

M. Garrigou, in the caves of the Pyrenees, has discovered, on a piece of slate, an outline of a bear, with convex forehead, contemporary with the primeval man who sketched him. M. Desnoyers and M. the Abbé Bourgeois have successively ascertained, in the neighbourhood of Chartres, the existence of fossil bones; among

others, of the *Elephas meridionalis*, bearing positive traces of incisions made by the hand of man with the assistance of implements of flint.

After this array of facts in proof of the antiquity of man, is it necessary to add that everywhere,—in Belgium, in England, in Germany, in Italy, in Spain, in the United



ENGRAVED OBJECTS FROM THE FRENCH BONE-CAVES.

States, in Brazil, in Syria, in Hindustan, in every locality which the geologists have examined,—similar discoveries have taken place, and that skulls and fossil jaws, with every appearance of authenticity, have been found in various places, more particularly in Italy, in the valley of the Arno ; in Belgium, in the caverns of the Meuse ; and have brought additional proof of the existence of antediluvian man ? It will not be one of the least significant conquests of contemporary geology that it has solved this great problem, a problem which was so long the perplexity of the world of science.

The existence of Primitive Man being thus established, what are we to say of his condition? Let us own the truth; we have very few data on which to form a judgment. As Dr. Tylor observes: "We nowhere find his ten commandments sculptured in picture-writing on a mammoth tusk; and if any of his moral precepts have been handed down by long tradition to modern times, these particular maxims can no longer be recognized in the world's heaped-up treasury of social science, to which hundreds of generations have brought their precious things. The only absolute testimony to the moral state of these rude prehistoric clans is, the very fact that they existed—that they existed for generation after generation. Clearly, man did not even in those wild days indulge his desires quite without restraint; he did not simply clutch whatever he longed for, and with his gnarled club batter in the skull of any one who stood in his way. Men and women must have had some restraint by way of marriage, some kindly care for children till of age to shift for themselves. These rough folk must have known how to live and let live, or they would simply have died out." In all other respects, their life was the life of the savage, and the first gleams of civilization do not seem to have dawned upon them.

CHAPTER III.

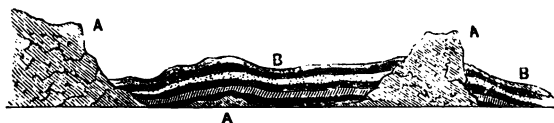
UNDERGROUND—METALLIC DEPOSITS AND THEIR FORMATIONS.

Sedimentary and eruptive rocks—Metamorphic rocks—Veins of metal—Theories of Descartes and Werner—Metallic deposits of the Primary, Secondary, Tertiary, and Quaternary rocks—Ribbon-like veins—Veins of contact—Metaliferous strata—Eruptive veins—Deposits in the drift—The mine: Roof, walls, and galleries—Condition of the metallic ore in the veins—The metaliferous chain of the Andes—Discovery of the silver-mines of Spain and the gold-mines of California—An unfortunate expedition—The commercial value of the Minerals and Metals—The Chinese—A Brilliant Transaction at Madagascar—How to secure a net profit of five millions.



IN examining the various formations of which the terrestrial crust is composed, we see that some extend in broad continuous masses, divided into beds with a greater or less inclination (or "dip"), and with parallel joints. They might not inaptly be described as the foundations of immense walls. The composition of each of these strata is homogeneous: either limestone, marl, carbon, clay, or sandstone. That these deposits are the result of aqueous action, cannot be disputed. We find in them the remains of organized bodies, shells, impressions of plants, bones; everything, in fact, popularly known as petrifications or fossils. Of these formations, the "coal-measures" are the most remarkable.

Others there are which present an appearance exactly the reverse of these. They are accumulated in abrupt and irregular precipices, rising to great heights. The superimposed strata have disappeared; the rock is absolutely compact, or divided only by irregular fissures. It has a vitreous crystalline aspect, as if it had passed through a certain stage of plasticity, and been exposed to the influence of a very high temperature. It seems to have emerged in a single mass from the internal depths, and to have forced its way through the rocks previously described, violently dislocating and upheaving their strata. No organic remains does it exhibit; no trace of life dating from the epoch when it was formed. Its substance is composed of heterogeneous elements,



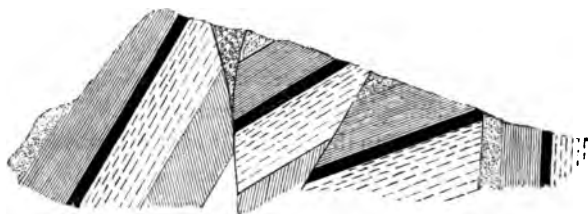
A, A, ERUPTIVE ROCKS. B, B, SEDIMENTARY ROCKS.

and crystals of various kinds may be detected in it. To this class of rocks belong the granites, porphyries, diorites, and other analogous rocks, as well as the volcanic.

The rocks first described are geologically named, as we have pointed out in a preceding chapter, *Sedimentary*; the others, *Eruptive*. The former also are named at times *Stratified*, *Aqueous*, *Neptunian*; the latter, *Massive* or *Crystalline*, *Igneous*, *Plutonian*. Designations borrowed from the ancient mythology were formerly in great vogue, as if, during its period of startling hypothesis, geology

had wished to keep close, as it were, to the shores of fable, even in the most general denominations which it imposed upon the rocks. This carries us back to an epoch whose last echoes were heard by our fathers; the epoch of the great geogenic controversies, when Neptunians and Plutonians, the last-named reinforced by the Vulcanists, carried on an incessant war of words.

The function of the eruptive rocks, in upheaving the sedimentary, was to raise along the meridian certain lofty chains of mountains, and communicate to our globe its present configuration. They have not only raised erect, but completely dislocated, the stratified formations, and



DISLOCATIONS OF STRATIFIED FORMATIONS BY ERUPTIVE ROCKS.

opened in them, often over a very considerable area, great fissures and broad furrows, such as are now produced by sudden shocks of earthquake. Finally, the vicinity or the contact of the eruptive rocks has changed the very appearance and composition of the sedimentary formations, which have been profoundly modified and absolutely transformed, wherefore they have been called *Metamorphic*. In this curious phenomenon certain rocks—as for instance the clays—have assumed a blackish or lustrous colour; pressure has developed in them a peculiar structure, parallel fissures, and delusive planes of stratifi-

cation. Finally, new substances, such as talc or mica, have been engendered there or introduced ; in this way have been formed the micaceous and talcose schists, which derive their name from the new element they embody, and serve as a transition between the eruptive rocks and those sedimentary rocks which have remained uninjured and intact.

It is among the fissures of the schists, or even between their layers, that the metallic treasure-houses, technically known as *veins*, are chiefly deposited. But how is the operation of filling these fissures and interstices performed? It is not easy to reply. Plato and Aristotle, moved by that wonderful intuitive and divining genius of which they have given so many proofs, attributed it to the *central fire*,* and their hypothesis has been taken up by the most illustrious modern physicists, Descartes, Leibnitz, and Buffon. According to these naturalists, the metalliferous emanations issued forth in a state of vapour from Nature's great laboratory, which is ever at work in the centre of our globe, and were condensed as they mounted upwards. Dissatisfied with this explanation, however, some miners, following up the footsteps of other and less distinguished philosophers of antiquity, put forward a theory that the formation of metalliferous substances was continuous : asserting that they vegetated, or ramified into veins, in the same manner as the roots of a plant extend into the soil. The famous treatise, "D'Exploitation des Mines,"

* It has now been demonstrated, with a tolerable degree of accuracy, that the terrestrial crust reposes like a raft on a liquid sphere, a sea of fire. Supposing the globe reduced to the size of an apple, the rind of the fruit would represent the **terrestrial** crust ; its corrugations, the mountains and valleys ; its pulp, the incandescent sea.

by the German Delius, contains a chapter on the "Vegetation of Gold."

Such was the position of the question when the Saxon miner Werner, whom the Neptunians eagerly hastened to acknowledge as their chief, adopted, and for a long time ensured the popularity of, the idea of an *Aqueous Formation*. He imagined that the veins had been filled from above to below by the superficial waters penetrating into the fissures of the soil. This theory does not altogether harmonize with the facts: the majority of geologists, therefore, taking up again the hypothesis of Descartes, now admit that the filling up of the metallic veins generally takes place from *below* upwards, and that the metalliferous emanations are disposed in the fissures which constitute the veins, either in a vaporous condition, as in the vents of volcanoes or the chimneys of metallurgical furnaces, or in the condition of chemical precipitations, as in the distillations of our laboratories.

The formations of the Primary period are naturally those in which the greatest number of veins is met with. In fact, metal is never wanting when properly looked for. Granite and porphyry are pre-eminently the metalliferous rocks of that period; in other words, those whose appearance has originated the largest number of fissures, and, consequently, of veins, the growth of the greatest amount of metal.

The formations of the Secondary period, lying between the coal-measures and the lowest deposits of the chalk, contain far fewer veins than those of the preceding period,

and in the list of metals offer us only copper, lead, zinc, iron, and manganese.

In the Tertiary period, the number and extent of the beds are still more limited ; the eruption of the porphyries has long since ceased ; that of the granites is at an end. In this age, and in the preceding, certain peculiar deposits are formed, characterized by metalliferous rocks whose eruption only now commences,—the greensands. Other deposits extend in layers or in irregular masses into the grits ; pudding-stones, into the midst even of the sedimentary rocks ; finally, others make their appearance continuously, like genuine eruptive rocks, and are sometimes closely mixed up with these.

The Quaternary period, of which the present age is but the development, contains only some absolutely special deposits, formed for the most part of the débris of those of which we have spoken. These are generally known as *Alluvial Deposits* and *Placers*.

The veins whose mode of formation and filling up we have first explained are the *Classic Veins*, those which French mineralogists designate *filons-fentes* or *filons-faillés*.

Sometimes they are known as *Regular Veins*, as much on account of their nature as because they obey certain well-known laws. Finally, they are also known as *Ribbon-veins* (*filons rubannés*), because their filling up having frequently been a series of operations, and not one continuous process, parallel bands of mineral and *gangue*

follow one another in almost mathematical order, and as if each of them occupied a preordained position. The veins of Saxony and the Hartz are, for the most part, "ribbon-veins," and the very type of that kind of veins.

The fissures in the "ribbon-veins" not having all been produced at the same epoch, and the process of filling up having been protracted over a very long period, it happens that the more ancient veins are frequently crossed by the more modern. Generally a fault takes place at the point of intersection, which throws off the more ancient vein. The composition of the veins also is usually different; the nature of the metalliferous emanations has changed in the course of time.

When all the veins are filled with the same metallic matter, it frequently happens that they grow richer at the point of junction.

The intersecting vein is called the *crosser*; the vein intersected is the principal vein. In the aggregate these veins, in certain metalliferous regions, present upon the map a curiously complicated network. The miners have certain practical rules by which they find their way into the midst of the labyrinth, and strike unerringly upon the veins intersected by the cross-veins. The general configuration of the soil, in fact, is not without some analogy to the subterranean disposition of the metallic deposits.

The direction, or *alignment*, of the principal vein agrees with that of the grand mountain-chains of the country, and frequently the intersecting veins strike along the buttresses or secondary chains of the country.

The regular veins are generally of an inconsiderable thickness,—seven to ten feet at the utmost. When this

thickness is exceeded, and the mass of the vein is composed of an uniform substance, in which floats, as it were, the metalliferous portion, it is called a *dyke*; and this word, which signifies an embankment or barrier, well describes the appearance which the vein then assumes. It is a true wall of stone, deep sunken in the earth, and filling up the enormous chasm opened by some convulsion in antediluvian times.

The veins, or lodes, though forming the most interesting class of metalliferous deposits, are not the only ones worked by the miner. There are also the "veins of contact," the "eruptive veins," the "stratified veins," the mass-deposits, which may fittingly be comprehended under the general denomination of *irregular* deposits in opposition to the foregoing.

We shall attempt to explain, in a few words, the characteristic features of each of these new formations.

"Veins of contact" are those which fill the fissures occurring between the eruptive and the pre-existing rock, where the latter was upheaved. They derive their name from their being in contact with both the later and the earlier formations. In these cases the eruptive rock is always found to be largely metalliferous; a fact to which the fissure was due, and the filling up of that fissure with the metallic ore. The rocks known to German geologists as *Grunsteins*, to the French as *Roches Vertes*, and to the English as *Greenstones*, such as the diorites and serpentines, are the most productive metalliferous rocks, and the most abundant in "veins of contact." The metal generally met with in these lodes is copper.

"Veins of contact," in certain circumstances, connect themselves with the ordinary veins; but are usually separated by the very distribution of the ore, which is always irregular and uneven, or is governed by laws of which we have as yet no accurate conception; while in the right-running veins the "lay" of the deposit is normal, and may to some extent be determined beforehand.

"Stratified veins" (*filons couchés*) do not form so widely-extended a class as the preceding. They are characterized by the existence of the metalliferous deposits between the actual strata of the sedimentary rocks, and hence derive their name.

When they result from particular processes, such as those which have effected the modifications of the sedimentary rocks, they are known as "metamorphic veins." Some deposits of mercury, lead, and copper belong to this class.

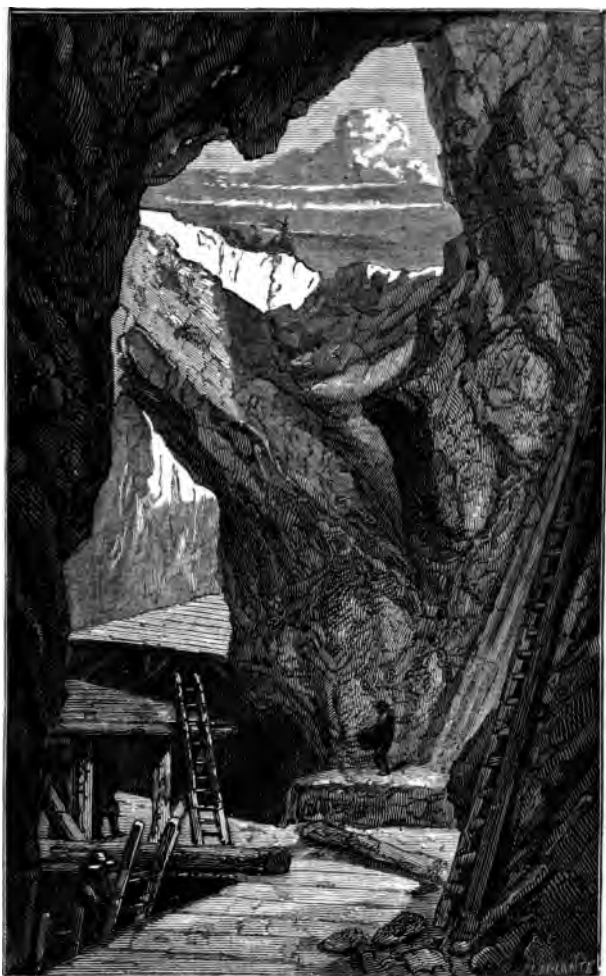
The reader must not confuse the "stratified veins" with those genuine metalliferous beds which are found in the very heart of the sedimentary rocks, regularly intercalated between, and forming a part of, the strata of these rocks. In this shape the carbonate of iron presents itself in the coal-measures. Specular iron and manganese are also found in regular beds in the Secondary and Tertiary formations. The ancient forge-masters, under these circumstances, christened the iron ore with the name of *mine en roche*, to distinguish it from the ore yielded by the veins, which they called "mountain

ore." We may easily account for the formation of these ferriferous or manganesian beds by the deposit from mineral springs, heavily loaded with metallic elements.

Like iron and manganese, only more rarely, copper and iron are met with in the sedimentary rocks in the condition of strata or layers. They are found more particularly in those coarse-grained silicious sandstones, those pudding-stones, and breccias, which are known as *arkoses*, and which form the bases of some of the Secondary deposits. These transported rocks belong to a stormy period, followed by a sudden calm. No doubt the metalliferous particles which they contain have been frequently swept away from their original habitats, rolled to and fro by turbid currents, and carried, along with various stony substances, to the place of final deposit, where all these elements have gradually been welded into an aggregate.

The "eruptive veins" (*filons éruptifs*), of which we must now speak, present a considerable analogy to the "dykes;" only they as much surpass them in solidity as the latter surpass the "vein fissures." Thus, there are eruptive veins which attain a thickness of upwards of 350 feet. Moreover, their mode of formation differs from that of the "vein fissures" and the "dykes."

There are two classes of "eruptive veins." In the first, the eruptive rock is itself the metallic rock, in the absolute meaning of the word. The ore has been injected in great masses while in a molten or *doughy* state. To this class belong numerous beds of black oxide of



IRON-MINE OF DANNEMORA, SWEDEN.

iron and iron pyrites, such as those of Dannemora in Sweden. In the second class, the eruptive rock exists independently of the ore, which is found irregularly distributed in veins and veinlets, "bunches," "strings," "threads," "pipe-veins," and the like. Some green rocks, as the amphiboles and serpentines, inclose in this way copper ore. Gold, platinum, and oxidized tin are found in similar shapes in granite. And lastly, the metalliferous dykes of quartz are also connected with this class, if we regard them as eruptive.

The "mass-deposits" (*gîtes en amas*) with which the series closes are, pre-eminently, "irregular deposits." They may be divided into "mass-deposits," properly so called, and into "alluvial deposits." The former occupy those more or less extensive subterranean cavities which occur in the heart of the sedimentary formations, and are specially rich in copper, iron, and zinc ores. When the bed is exhausted, we may say that the miner has seen "the bottom of his purse." The copper-mine of Fahlun, in Sweden, in which a very curious mode of descent, by a kind of double ladder, obtains, may be cited as a classic example of a mine wrought in a mass-deposit. The ore is mixed with iron pyrites, and is found included in quartzose and amphibolic rocks.

The celebrated silver-mine of Konigsberg, in Norway, is likewise excavated in an immense bed in the gneiss or schistose granite.

The "alluvial deposits" compose a very interesting



DESCENT INTO THE COPPER-MINE OF FAHLUN, SWEDEN.

class, which comprehends either iron and manganese ores, or ores of tin, platinum, and gold. Among the latter we may point to the *placers* of Siberia, California, and Brazil, with which are mingled, particularly in Brazil, certain diamond-yielding beds.

Let us now return to the true metallic veins, the vein-fissures, for the purpose of studying their "lay," composition, and subterranean aspect.

In accordance with what we have already said, we may picture to ourselves a vein of metal as a wedge or table-shaped mass sunk in the depths of the earth. The portion which shows itself on the surface is known as the "level" (*affleurement*), or "head" of the vein. The Germans call it *eisenhut*, or the "iron cap," because it is generally composed of black oxide of iron ore, more or less modified, mixed with a certain amount of quartz or rock-crystal. The miners, as a rule, determine the richness of a bed by the abundance and appearance of the *eisenhut*. It is a rule which obtains in many mines that a decomposed, scoriaceous, terreous "iron cap," with reddish tones, authorizes the most sanguine hopes. In Cornwall the vein-seekers look upon this rule as infallible. One of their maxims is: "A good silver vein always wears an iron cap." And as the intact common iron pyrites, which they call *mundic*, frequently announce, in the interior, the presence of the workable vein which they call the *horse*, they are also accustomed to say: "Mundic rides a good horse."

The miners of Mexico and Peru are also guided by the "heads" of the argentiferous veins, reddish and blackish pulverulent substances, *Colorados*, *Negros*, *Pacos*,

..... SUPPLE, COLORADO.



and the like. When first discovered by the followers of Cortez and Pizarro, these earths contained enormous accumulations of silver, by which the early settlers were largely enriched.

In California, the veins of quartz are likewise furnished with "iron caps." It is the disintegration and the denudation of the superficial levels of these deposits *in situ*, which, as a rule, have brought down the gold into the *placers*. The auriferous valleys are, in fact, nearly always subordinated to the veins which run along the ridges and higher grounds.

The "heads" of copper, lead, antimony, and zinc veins are distinguished by peculiar characters analogous to those of the "iron caps." The ore which, underneath, is a *sulphuret*, a combination of the metal with sulphur, has been gradually modified on the surface by the prolonged action of atmospheric agents. It has passed into the state of an oxide, a carbonate, or a sulphate; and thus are formed those abundantly rich concentrations which have frequently inspired explorers with an exaggerated idea of the value of the deposits lying below.

Let us now trace the subterranean course of the veins, the superficial appearance or outcome of which we have been studying. Whether they strike across the sedimentary beds in whose midst they are intercalated, or whether they run parallel to their stratification, vein-fissures, dykes, and "veins of contact," we distinguish the "walls," or portions of rock which inclose them into the *floor* and the *roof*. The "floor" is the plane on which the vein reposes; the "roof" is the opposite plane, which separ-

ates the vein from the rock above. If the vein have a considerable inclination, its upper boundary is termed the "hanging wall," and the lower the "foot wall." The interval between the two planes forms the thickness or richness of the deposit.

The wall and roof are sometimes formed of those smooth, polished, striated surfaces which the miners name *mirrors*, and which account very plainly for the violent movements produced in the soil by the formation of certain veins. Gray or whitish, argillaceous, and schistous substances frequently occur both in the roof and the wall, as if justifying, in this instance, the Wernerian theory, superficial infiltrations having accumulated in the plane of the vein.

It is interesting to study the distribution, condition, and arrangement of the ore in the deposit underneath the surface-level.

In some veins the ore is regularly distributed throughout the mass in parallel bands; in others, it looks as if it had been injected haphazard.

Here it is the roof, there the wall, which concentrates the precious material; at other points, the ore prefers to follow certain lines, and accumulates in what the miners call "bunches." It might almost be said that the metallic effluvia have followed the track of certain chimneys, as it were, or canals opened under the soil, in which, the resistance not being very great, they have found ample room for expansion. Sometimes these metallic concentrations are regular and continuous throughout the entire length of the lodes, which are situated at nearly equidistant intervals. At other times they are themselves intersected

and broken up, and in such circumstances they form *threads, strings, or pipe-veins*, of which the law of distribution remains, in most cases, absolutely unknown both to the geologist and the miner.

It is not without reason that we have compared to a wedge the general shape of the veins. This figure, in certain circumstances, is literally verified. The surface-levels there present the maximum of thickness, while the



METALLIC VEINS.

vein diminishes as it sinks more and more deeply into the earth. The richness of the bed generally follows these variations, and the mine eventually disappears altogether. An example occurred a few years ago (1865) in the lead and silver mines of Poullaouen and Huelgoët (in the department of La Finistère, France). The works had to be abandoned at the depth of 1600 feet on account of their sterility, after having been worked for several centuries.

A very general form of the deposits is the so-called *tabular*, presenting the appearance of a body limited by two parallel planes, which supposes an almost indefinite depth. The veins of Saxony and the Hartz, always famed for their productiveness, even at a depth of upwards of 2700 feet, a depth which has now been attained, belong to this category.

Finally, the configuration of certain deposits may be compared to that of one of those roots which, in botany, are named "tap-roots," because they strike perpendicularly into the soil like a pin or spindle. The resemblance is complete: the ramifications of the vein correspond to those of the root; and more, the thickness increases from the surface towards the centre of the vein, and from that point gradually decreases. Sometimes it tapers off to nothing.

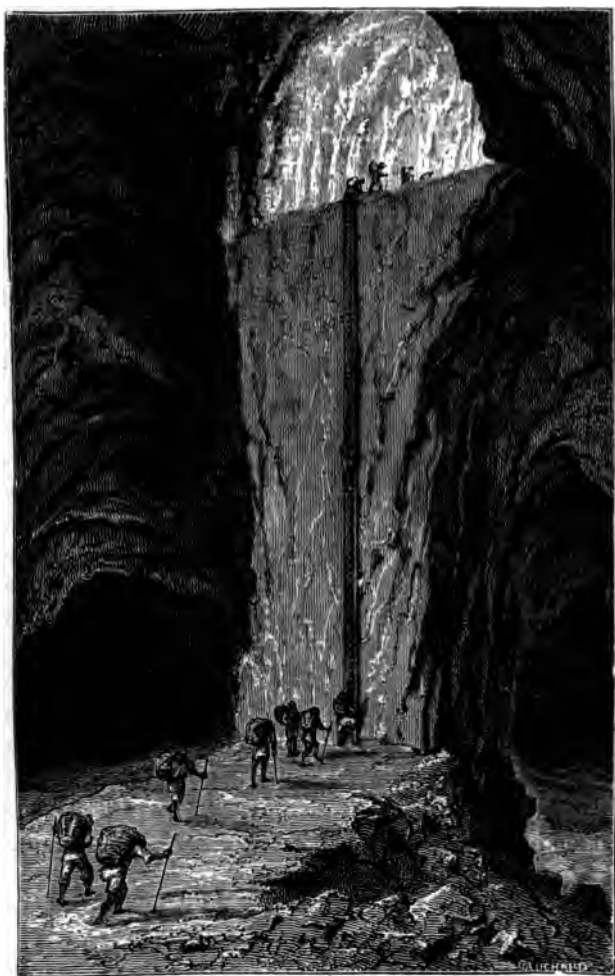
In many cases it is not only the thickness of the veins which augments with the depth, but also the richness—at least to a certain distance. In 1860 there was worked in California, in the county of Mariposa, a vein of auriferous quartz, the thickness of which at the surface did not exceed 3293 feet, and its wealth £2 worth of gold to one ton (or one thousand kilogrammes) of ore. At 150 feet deep the thickness was 6556 feet, and the value of the metal equalled £4 sterling.

But, starting from a certain limit which varies in every deposit, this law of the increase of value and increment of thickness ceases to hold good, and the exact inverse obtains. It may be said, by way of explanation, that the metallic matters held in suspension are unable to precipitate or deposit themselves when the pressure is not very

great. In some mines it is the upper strata—I do not mean the superficial, which are always the richest—that exhibit the greatest productiveness. Is this because all veins exhaust themselves as they strike downwards? This question is, we take it, one of the gravest connected with mining. For some years opposite sides with respect to it were taken by two well-known French mineralogists, MM. Pernolet and Burat. Each of them cited apparently conclusive facts in confirmation of his own view. M. Pernolet advocated the disappearance, M. Burat the continuity, of the metallic ores beneath the surface. The reasons which each brought forward were very just ; but then they were foiled at the outset by the erroneousness of their premises. On this point no absolute principle can be laid down, and each case must be treated independently and distinctly.

We have said that, so far as concerns the majority of the veins, the thickness and value increase in proportion to the depth to which they strike. But things are even better : frequently the composition changes, and not only does one and the same family of minerals exhibit its oxidized ores at the surface, and its sulphurets underground, but we pass from one family to another ; thus, from lead ores to copper ores, and from copper ores to tin ores, as in the case at the Botallack Mine of Cornwall, at the Land's End, where these veins are worked even under the bed of the ocean.

In a similar manner, in the mines of Chessy, near Lyons, which have so long yielded, near the surface, the most beautiful azurites known (blue carbonates of copper).



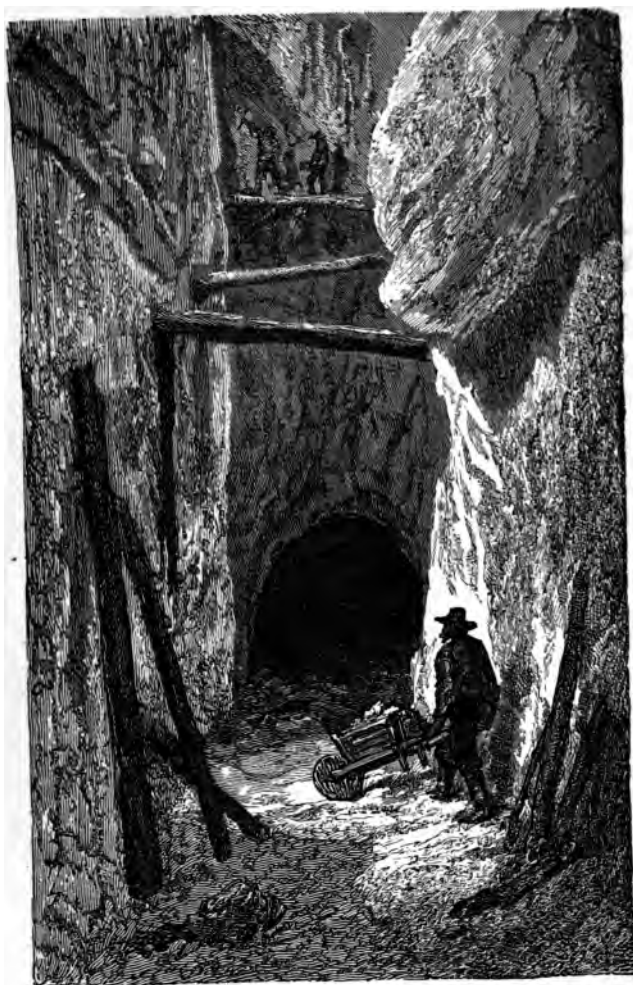
SILVER-MINE OF POTOSI, BOLIVIA.

the miners have successively alighted on copper and iron pyrites.

But if variations are to be detected in one and the same fissure, in the same locality, much more must we calculate upon meeting them in passing from one district to another. These fractures, filled up after they were made, which constitute the veins of ore, frequently extend, it is said, immense distances. Like certain mountain-chains, along which they are disposed, they outline themselves regularly upon the semi-meridians; in other words, they sometimes comprehend one half of a great circle of the sphere. Such is the great fracture which, along the Andes, supplies Chili with its treasures of copper, gold, and silver; Bolivia, with its silver,* copper, and tin; Peru, with its silver or mercury; New Grenada, gold and platinum; Central America and Mexico, gold, silver, lead, mercury, copper, tin, and iron; Nevada and California, gold, copper, mercury, silver; Oregon and British Columbia, with gold; and Alaska, with copper.

The direction of the Andes, in South America, oscillates around an axis situated north and south. This axis runs from north-west to south-east in North America. In both countries the fractures follow respectively these directions, but they are filled with different ores, according to the localities where the beds are worked, as if the nature

* In Bolivia lies the famous silver-mine of Potosi, which, from the time when the Spaniards began to work it down to 1800, so for nearly two centuries and a half, has yielded a sum of five milliards of shillings in silver ingots. But what is this compared with the outcome of the Californian mines, which, in less than twenty years, have poured into the United States upwards of three milliards of shillings in gold (1847-1867)?



GOLD-MINE OF EUREKA, NEVADA.

of the emanations had changed with the shafts of the central furnace whence they issued.

Though all the metalliferous regions are now tolerably well known, the discovery of the veins is due most frequently to accident. We cite a few examples from among a thousand. Neither the men of science, nor the geologists, nor the engineers come to the front in these discoveries, but poor peasants or poor artisans. Let us see how some of the most celebrated of the Spanish silver-mines have been discovered.

On the barren declivities of the Sierra de Gador and the Sierra Almagrera grows the coarse esparto grass, well known for the flexibility and tenacity of its stem. The native inhabitants have rendered this grass useful in a variety of ways. They twist and coil it into cables, panniers, mats, pack-saddles for mules, and even into sandals. It is a precious resource for that part of the Spanish littoral, and, at the same time, is valuable as an article of export. The panniers, pack-saddles, and cordage are sent as far as Marseilles, where they find a ready market. We have seen these panniers, under the Southern name of *couffins*, which indicates a Greek and Latin origin (*κόφινος*, "cophinus"), employed in the coal-mines of Provence. Upon all the quays of the ancient Phocæan colony (Massilia), the *couffin* and even the cordage of esparto play an important part also in the embarkation and disembarkation of merchandize. And, finally, the esparto rope is largely used in wells for lowering and raising the buckets. But even here we do not conclude



GATHERING ESPARTO GRASS.

our enumeration of the useful properties of the esparto grass ; for it is coming into use in England as a substitute for rags in the manufacture of paper.

Now one day, in 1838, a muleteer and a peasant of the Sierra Almagrera, working together at the collection of the esparto, were slowly climbing the steep acclivities of the mountain. One of them had long remarked with curious eye a number of ochreous rocks projecting along the path, and on this particular day they more than ever excited his attention.

"Suppose," he said to his companion—"suppose we were to dig a little over there."

His suggestion was acted upon, and scarcely had they dug a foot or so before they discovered some brilliant bits of galena ; that is, of sulphuret of argentiferous lead. It was the surface-level, or head, of the rich and massive vein since called *Jaroso*, which led to the formation of the great company of the *Virgen del Carmen*.

The discoverers were named Andreas Lopez, *alias* Perdigon, and Pedro Bravo Perez.

Each of them secured in the Company one-fourth share, valued at about £6. Soon afterwards Perez, being unable to pay his part of the monthly outlay, sold his fourth for a she-ass and a little mule.

In 1844 that same fourth was valued at £7900.

It is but fair to acknowledge that some writers relate in a different manner the discovery of the *Jaroso*. If the new version is true, it affords one of the very few instances of the discovery of a mine by science.

They assert that an officer, struck by the abundance of articles of galena which the inhabitants of the provinces of Almeria and Murcia had possessed from time immemorial, under the Arab designation of *alcool* (in French, *alquifoux*), and had made use of to varnish their pottery-ware, conceived the idea of testing the ore. To his surprise, he discovered in it silver of the value of 8 kilogrammes, or £63 sterling per ton. Immediately he obtained a concession of the mine *Carmen*, which it is said furnished in twenty years (from 1838 to 1858) £5,140,000 to its fortunate proprietary.

Generally the value of the argentiferous galenas does

not exceed a maximum of three to four millièmes per ton of ore. In Spain it sometimes descends to less than one-tenth millième. These figures will account for the exceptional richness of the *Jaroso*.

No sooner was this mine discovered, than Spain was seized with a general frenzy. The slightest ferruginous tint set men to dig lustily and willingly, and for the adventurous *rebuscadores* Spain became a miniature America. In less than eight years,—from 1840 to 1848,—twelve *pertenencias* or concessions produced upwards of £3,750,000 in lead and silver. Was not this temptation enough for hungry fortune-seekers?

The manner in which the gold-mines of California were discovered is not less curious than that of the discovery of the Spanish mines of silver. We know that it was also due to chance, and that it was made by a Mormon workman employed in a saw-mill belonging to Captain Sutter.

The career of this colonist had been singularly stormy and adventurous. Originally a captain in a Swiss regiment in the service of Charles X. of France, and himself a Swiss by birth, he quitted France after the revolution of July 1830. At first he settled in the United States, at New York; afterwards, at St. Louis. Nine years later, a pioneer of civilization, like so many other restless spirits, he crossed the wildernesses of the Far West, and located himself in the interior of California. Near the site of the thriving modern town of Sacramento, he started as a farmer. He cultivated the ground, and cleared the neighbouring wood. He had erected a fort

to repel the attacks of the Indians, against whom he mounted guard with thirty resolute pioneers, those famous Californian trappers who then overran the country. Finally, on the bank of the so-called *American River*, he built a saw-mill, at about fifteen leagues from his fortress, which, I may add, he had named New Helvetia, in honour of his absent country. You may see it marked on the maps of California produced prior to the year 1848.

New Helvetia became, in due time, the great entrepôt of the furs collected by the trappers; it was also a hospitable resting-place for the pioneers who from the Mississippi states began to pour into California. The distinguished explorer, Frémont, stayed there in 1844.

The year 1847 was the epoch of the celebrated migration or hegira of the Mormons, when driven from the states of the Union as enemies of the public weal. One body of these remarkable enthusiasts accomplished its exodus by crossing the Rocky Mountains, with the view of effecting a settlement in Utah, near the Great Salt Lake; while another detachment arrived by sea from New York, taking the Sandwich Islands on their way. Some of them who had come by the latter route, finding themselves at the end of their resources, entered into Sutter's service, and it is to one of these, the American Marshall, that the honour belongs of having discovered the first signs of Californian gold.*

* Such is the version given by M. Jules Rémy in his book on the Mormons. Others say that Marshall had been engaged in the Mormon battalion which had done good service in the Mexican war, and had been suddenly disbanded in California, contrary to the laws of the United States. The volunteers ought to

The discovery was made in the canal which carried the waters of the river to Sutter's saw-mill. The circumstances attending it are differently related. According to the narrative told, it is said, by Marshall himself, it seems that in allowing the water to flow into the canal which he had just excavated, he suddenly perceived a nugget. This, it appears, was on the 20th of January 1848. Marshall and Sutter, unable to believe their eyes, made various experiments to convince themselves that the pebble found by the former was really and truly gold.

M. Marcou, however, relates in a different fashion the incidents attending the discovery of gold in California. He says—and he obtained his details from Captain Sutter himself—that it was made by the children of Marshall and those of another Mormon, his fellow-workman. The boys were amusing themselves by digging among the pebbles of the mill-stream, which was dry in some places, where they found some *yellow stones*. These they carried to their parents, saying that they had had a fine game with “rolled dollars.”* The pebbles so happily characterized by the children were those lumps of ore in which men of a little experience had long learned to look for gold.

Shall we accept the first version of this remarkable incident, or the second? We cannot determine, for no

have been brought back, before being dismissed, into the state where they had been enlisted. These had been enrolled in the plains of the Missouri, at Council Bluff (the Mormons had already been compelled to quit Nauvoo), and the Government, in disbanding them abruptly, hoped to break up the sect, inasmuch as the battalion contained all the real strength and pith of the then infant Mormonism.

* These pretty American dollars are much used for making buttons and studs.

authentic and official account exists, so far as we know, of the discovery of gold in California, notwithstanding the great influence it has necessarily exercised upon the fortunes of the Pacific states.

At all events, this felicitous discovery verified the legendary tradition of the ancient Mexicans, afterwards transmitted to and handed down by the Spaniards, of a *Dorado*, or Land of Gold, situated towards the north, and on the shores of the Pacific. It is asserted that the early Christian missionaries, or perhaps the Indians themselves, knew of the existence of this gold, at least in the southern parts of the country, but kept it concealed for various reasons. Of this statement, however, no confirmation can be found.

It would appear, too, very improbable that other colonists, and notably the Americans, should have had any knowledge of the wealth of the auriferous lands of the great province, at all events throughout its whole extent.

It is, then, to the year 1848, and to the series of facts which we have just recorded, that we must refer a discovery which, when made, excited so universal an interest, and which drew to the shores of the Pacific the adventurous spirits of half a hundred nations. They poured into California from east and west, and north and south, all smitten by a feverish thirst of gold! Many were successful in their quest, and accumulated enormous fortunes; but, alas! a far larger number perished miserably, and left their bones to whiten on the desolate Californian plains—a significant warning against man's frenzied devotion of soul and body, heart and brain, to the accursed service of Mammon.

The following amusing story is related by M. Simonin, who vouches for its truth :—

In 1856, he says, I was residing at Marseilles, where I was employed in the offices of the Administration of Mines. Trade and commerce were at that time flourishing extensively, for merchants as yet had experienced no great panics, such as have marked the last twenty years.

A solicitor, one of my friends, M. R——, received a visit one day from his *fumiste*, a Piedmontese: by the way, all the Piedmontese emigrants are *fumistes* at Marseilles as at Paris. He held in his hand a magnificent specimen of galena, or crystallized sulphuret of lead.

"What is this?" said the solicitor.

"Oh, nothing! A stone from my country."

"What? Do stones like these run about the streets in your country. Leave it with me."

"Take it, sir; we have mountains of it in my native land."

"I will look after it."

M. R—— brought the specimen to me to be analyzed. It contained no less than .70 of lead, and .006 of silver.

A few days afterwards, the *fumiste* returned.

"Good day, sir."

"Good day, Andrea. Ah, well, when do we start?"

"Start! Where to go, sir?"

"To see your mine."

"To-morrow, if you like, sir."

"Be it so."

On the following evening, a clumsy steamboat, which never undertook more than a lumbering coast-voyage from Marseilles to Nice and back, carried towards the latter city three passengers.

Never before had her captain received so many on board!

The three passengers, as the reader will guess, were the solicitor, temporarily deserting his legal studies for a mountain expedition; Andrea, who went as scout; and myself, as consulting engineer.

The outset of the voyage was not very lively. We experienced one of those sudden gales common in that part of the Mediterranean.

It brought with it a storm of rain, which for twenty-four hours confined us below decks, in our narrow and only cabin.

Having at length reached Nice, we took the diligence for the Col di Tenda.

The rain which had afflicted us at sea was now changed to snow upon the Piedmontese highlands ; and snow so dense, that, notwithstanding the season was far advanced—it was near the end of May—we could cross the col only in a sledge.

I have seldom been present at a more perilous descent, and I can still hear one poor lady, of whom fate had made me the companion, recommending her soul to God. In the face of the tremendous precipices, down whose rugged steeps a false step or a momentary inattention on the part of the sledge-drivers might dash us headlong to destruction, I did not myself feel perfectly composed. Andrea and M. R—— followed in a second sleigh.

At Cuneo, the limit of our second stage, we engaged a vehicle to take us to Demonte, a small town at the foot of the mountains, as its name (*Pè de monie*), though corrupted and mutilated, shows.

In the plains the landscape again smiled with verdure ; it was the boundary of those beautiful meadows which, continuing Lombardy, as it were, into Piedmont, lie unfolded like a map between Turin and the Alps, and bloom with maize and hemp and mulberry-trees. The road extended before us like an uncoiled ribbon, and the chariot we had hired at Cuneo carried us along at a splendid rate. The rain of the day before had refreshed the young foliage, and among the branches the birds were singing blithely.

Everything contributed to our enjoyment.

My companion said to me :

“I have an aged father, who, during the Republic and the Empire, made war upon the seas like a corsair ; he is still full of energy and vigour, and would be glad of an occupation. I shall send him here to end his days, as the overseer of our works ; for, of course, we shall melt the ore. Here the sky is pure, and the country magnificent ; decidedly, the whole affair pleases me very much.”

During this conversation, Andrea, accustomed to the beauties of his country, was fast asleep.

We soon arrived at Demonte.

The *fumiste* conducted us to the inn, which was situated near his father's house.

For supper we were treated to trout freshly caught in the Stura, a bright, fresh stream, which, having its birthplace amongst the glaciers, descends into the lowlands with a rapid current.

Next day, well supplied with provisions, and accompanied by several guides, we took the road to the mountain. We climbed first one acclivity, and then another. The soil consisted of green serpentine-like rocks, and of shiny, smooth, but dull-coloured schists, which rose to very considerable elevations, and gave the scene a majestic and somewhat severe character.

We fell in with woodmen and shepherds, but as we ascended they grew fewer and still fewer, until we were left wholly to our own society. The silence and the solitude made my friend, the solicitor, reflect.

"Suppose," he whispered, "these mountaineers should prove treacherous, and that Andrea has brought us here to assassinate us secretly. I have all my money about my person."

But Andrea was thinking of something very different; he was in the company of his countrymen, and his tongue went like the pendulum of a clock. "And Beppo, is he still with his regiment? Is the fair Angiolina married at last? And does Micaela still torment her unfortunate husband?"

At length we reached the limit where the Alpine snows begin. We looked at Andrea.

"Higher still, gentlemen! Courage!"

We sunk knee-deep into the snow; a dense mist concealed from our eyes the sun, and at length effectually hid us from one another.

We could not see two paces in front of us.

"I think my last hour has come," whispered my companion, who had never before shared in so desperate an adventure.

"Do not be afraid," I replied; "there are others besides ourselves who have undertaken this enterprise."

"And the vein of metal! When shall we see it?"

"That is my business," I rejoined.

And for another hour we continued the painful and difficult ascent. Before us rose Monte Viso with its crest of ice; then peaks and peaks accumulated one upon another—rounded peaks, whose names, however, I could not trouble myself to ask.

"Well, Andrea, when shall we reach the mine?"

"Sir, I am looking about for it in all directions; but I do not know -the snow and ice—" And the rustic began to stammer.

Suddenly I felt as if a veil had been torn from my eyes.

"Scoundrel," I exclaimed, "you have deceived us! The mine exists only in your imagination!" And I raised my cane to strike him.

M. R—, less excited, parried the blow, while Andrea muttered between his teeth that he would be revenged upon me.

We began our descent, dividing into two parties—M. R—, myself, and one of the guides; Andrea, to whom we did not deign to utter a word, and his friends. Late in the evening we arrived, completely exhausted, at Demonte.

The penetrating mist which had enshrouded us on the heights, and the snow reflecting the light and heat upon our face, had produced a singular effect: face, neck, hands were as red as a boiled lobster, the consequence of our neglecting to wear coloured veils.

For a whole week we did not recover from this *coup de soleil*, and we literally shed our skin like a serpent in spring-time. M. R— sent for the barber, but he only made the pain more excruciating. Moreover, he suffered from other woes. Before blowing out his candle, he looked under the bed to see if Andrea were hidden there; then, making me a sign, he pointed to a pair of pistols which he concealed under his pillow. "When on a journey," said he, "it is advisable to take every precaution." The solicitor travelled in as warlike guise as his ancestors a century before.

On the following day, as we were preparing to quit Demonte, one of Andrea's friends presented himself deferentially before us, and in Andrea's name handed us an old parchment, which we forthwith proceeded to unroll and decipher. It was written in the dialect of the sixteenth century:—

"Starting from the stone which stands at the north angle of Agostino's field, count forty steps in front of you. There you will find a slab, which you must upraise; it gives access to a well, at the bottom of which you will find a treasure."

"With this paper," said Andrea's friend, addressing me, "mon-sieur the engineer will discover the mine."

We shrugged our shoulders, and started on our journey, leaving Andrea behind us. He might, if he chose, return to Marseilles at his own expense, and practise there as a chimney-doctor; or, if such were his good pleasure, undertake the discovery of the treasure at the bottom of the well.

We repaired to Turin to console ourselves for our disappointment; but I was unable to make use of the letters of recommendation with which I had been furnished. All the skin was coming off my face in shreds. My companion suffered in the same way; and we durst not present ourselves in such a condition before the eminent Piedmontese to whom our letters were addressed. At the hotel where we lodged the servants regarded us as veritable *Redskins*, and we took our meals in our own apartment that we might not discommode the guests at the *table d'hôte*. We gained admission to the Chamber of Deputies, however, as *forestieri*, or strangers. There I heard the great Piedmontese statesman, Count Cavour, discussing a financial question with the lucidity which was so eminently a characteristic of his intellect. We were seated in the rear of the deputies, and observed that some were reading the foreign newspapers. The French language—the use of which was allowed, as well as the Italian—was employed in the tribune by some of the Savoyard orators. There rose from this assembly of the legislators of a small but progressive state a certain perfume, as it were, of liberalism, which made upon us a permanent impression. We left Turin, that patriotic capital, carrying away with us the most delightful memories. Everywhere we had found a ready and cordial welcome, and we visited the palace under the very eyes, so to speak, of the king.

We returned from Turin to Genoa, and from Genoa to Nice by the famous road of the Corniche. This road is excavated out of marble mountains on the border of the sea. Frequently it encroaches on the waters, and when he traverses the *marines* along the coast, the traveller passes under the bending masts of fishing-boats hauled up on the beach.

At Nice—already deprived of its English visitors—we were compelled to resort to our umbrellas for protection against the burning rays of a tropical sun. The French custom-house officers, vigilant

and incorruptible, made us pay at the frontier a tax upon our umbrellas as heavy as that on merchandize, undoubtedly for the encouragement of the national industry. The pistols which M. R—— had left in one of the pockets of the diligence nearly cost him dear. The principal officer, in the course of his researches, came upon them. He wished to seize them as an object of contraband, or, at least, to make us pay duty on them, *because they had not been used*. The debate was lively, and terminated to our advantage; but it was fated that to the very end our expedition should prove unfortunate.

At length we traversed the plains of Cannes perfumed with the breath of roses.

R—— returned alone to Marseilles, while I halted at the Esterel to examine some mines of a more genuine character than those of Demonte.

Soon afterwards my friend received a letter from Andrea, promising to return in the summer when the snow had melted from the mountains, and he could show us the veins of ore!

The truth is, that we never again saw our Piedmontese chimney-doctor at Marseilles. One day, when I spoke to R—— of the unfortunate expedition which had cost him so much money,—

“Say no more about it,” he rejoined. “I have learned that the cheat picked up his specimens of galena on our quays, in a cargo of mineral ore which had arrived from Sardinia. He lied imprudently in telling me that it came from his own country; but he preferred to carry his deception to the very end, and drag us to his confounded mountains, rather than own that I had caught him in a fib. After all, he may have wanted to see his family and return to his country without paying for the double pleasure. As for myself, it is the first and last time that I will meddle with mines. I prefer to engross my parchments.”

We know, however, that the working of metallic mines has some better object than simply to furnish a bait for human cupidity. It is the source and support of a two-fold industry—subterranean and metallurgic—and furnishes commerce with the elements of operations as varied as they are numerous.

The traffic in ores and metals is carried on in the present day at numerous marts. In the United States we may name New York for iron ; Boston and Pittsburg for copper ; Galena and Chicago for lead ; San Francisco for gold, silver, and mercury. In Mexico, the principal depôts for silver are Mazatlan, San Blas, Acapulco, and Vera Cruz ; and in Peru, Callao for silver ; in Chili, Huasco, Copiapo, and Coquimbo for silver and copper ; in the Brazils, Rio Janeiro and Bahia for gold.

In Great Britain, Swansea and Liverpool are the great entrepôts of copper ; Glasgow and the Welsh ports, of iron and smelting ; Sheffield, iron and steel ; London, all the metals.

In France, we may name Paris, Marseilles, Havre, Nantes, and various places inland, such as Lyons, Saint-Dizier, and Saint-Etienne ; but these latter for iron, cast-iron, and steel only. In Spain, Carthagena, Almeria, and Adra are the principal marts for lead ; Almaden, for mercury ; and Santander, for zinc.

In Holland—Rotterdam and Amsterdam, for tin ; in North Germany—Hamburg, Cologne, Berlin, Stettin, Breslau, for iron, copper, zinc, and lead.

Sweden is famous for its iron marts. In European Russia and Siberia, there are also various depôts of copper and iron, without counting Nijni-Novgorod, where a celebrated fair takes place annually, and large quantities of unwrought metal are bought and sold.

As we have seen, it is in the busiest commercial cities that the largest markets are held of metals and minerals. Nor should this astonish us ; for it is easy to explain both the work of the precious metals, and the

function of the common metals, in the development of the public wealth.

The value of the imported metals enters always as a very considerable sum into the balance of the commerce of states. Consider how much of our national riches is owing to our stores of iron, copper, and tin ! Our iron industry is one of the great pillars of our prosperity. It is not too much to say, that were it annihilated the edifice of our power and wealth would speedily crumble into the dust. Some of our largest and most flourishing towns in the north of England are built, as it were, upon iron.

Nor do the precious metals play a less important part than the common metals.

If the latter intervene, in some way or other, in nearly every material act of life, furnishing us with almost all our tools and implements, all the apparatus of which we stand in need either in art, science, or industry,—the latter furnish us with the means of purchasing these things. But we must look at them from even a higher view-point. Gold and silver have been the parents of commerce by providing man with metallic money, the mathematical basis of values. When we do not produce these metals at home, we are compelled to go elsewhere and purchase them. “No money, no Swiss,” as an old proverb says.

The Chinese, who produce in their own country a very small quantity of gold and silver, and to whom Europeans must necessarily pay the price of the wares they buy of them—for they buy more than they sell—the Chinese always insist upon being paid in ingots of silver in default of Mexican or Spanish piastres.

They place less confidence in gold, whose yellow colour is less virginal in their eyes than the pure white of silver; and they are afraid of being cheated even with metallic coins which have a true ring and belong to genuine currency.

At Madagascar, in like manner, European silver only is admitted. The commerce of the country is inconsiderable; and, in truth, it has made no great advances in civilization. It is not ingots, however, which our merchants carry there, but French five-franc pieces, English crowns, American dollars, Mexican piastres, and, finally, the now very rare and much valued *pesos*, or *colonates*, of Spain.

To obtain the fractional parts of five francs, the Malagasy cut the coin into small pieces,—into pieces so small that they exceed even the centesimal limit. They carry their moneys about in a bamboo case decorated by native artists. When making a payment, the vendor, armed with a balance, whose weights have been officially tested, weighs the bits of silver, and then alternates the burden in the scales, putting the silver where the weights were at first, and the weights where the silver was. Both operations are accomplished with imperturbable tranquillity. No one is ever in a hurry in Madagascar. However, the want of a currency is beginning to be keenly felt in all commercial transactions.

In 1865, M. Simonin tells us, he met at Paris with a mercantile agent who, struck by these facts, had conceived the idea of supplying Madagascar with a small silver currency; and would perhaps have succeeded, but for the

violent death of King Radama II., who was assassinated in May 1863, with all his young favourites, or *menamasses*, in a domestic revolution.

The financier described his project to M. Simonin in the following words :—

“I am well acquainted with financial operations. In 183— I gained two hundred thousand francs from the Pasha of Egypt in a pecuniary negotiation. With Radama II. I gain five millions ready money. In this way :—

“There is no copper money in the country. Your broken bits of silver franc-pieces are good enough to amuse tourists, but are useless in commercial transactions. Now the island will shortly be colonized, as a result of the treaty concluded between France and Madagascar. I have my idea. The country contains, it is said, fully four million inhabitants. I calculate that each person requires five francs ready money. You will admit that my calculation is not extravagant. The total, then, is twenty millions. Radama concedes to me the privilege of stamping these twenty millions with his effigy. I send him my copper sous, guaranteed to be of French alloy and good weight. On one side, the figure of the young king, with the legend, in Malagasy,—

‘Radama II. manjaka ny Madagascar.’

On the other, the Madagascar eagle clasping the starry globe in its talons ; and the date, either the lunar or solar year as they will, or both if they so prefer it.

“Now let us calculate. Twenty millions of copper sous will cost me, at the most, ten millions,—the value of the metal, recasting, and stamping included. Allow five

millions for cost of transport, fees to the native officials, and other expenses ; and there remains a clear profit of five millions. Do not be afraid ; I understand this sort of speculation. In 183— I cleared two hundred thousand francs out of a transaction with the Pasha of Egypt."

But the misfortune was that poor Radama did not wait for our speculator ! The domestic revolution which terminated so fatally for the young sovereign swept away the treaty of commerce concluded with France, and the royal charter granted to the persevering and ingenious M. Lambert ; who, however, if he is alive, will still be looking out for an opportunity of resuming his clever monetary combination !

CHAPTER IV.

THE SALTS AND NATURAL GASES.

The great family of minerals—Old superstitions—The good old days of lithology—The seven members of the mineral family—Part played by each of them—The saline springs of the Carpathians and the Val-di-Cecina—The alum pits of Montioni—Fumeroles of boric acid—The Styx and Charon's boat—Sulphurous springs—Chalybeate springs—Petrifying waters and dropping wells.

P to the end of the last century, the scientific authorities of England, France, and Germany had made no attempt to classify and name the minerals. Those innumerable divisions and subdivisions which are the delight of physicists, but the abhorrence of the general public in their ignorance of Greek and Latin terminology, were not then invented. As a French poet sings :—

“ Nos pères, sur ce point, étaient gens bien sensés,”

[So far, our sires were men of sterling sense,]

who contented themselves with dividing the mineral world into earth, stones, salts, combustibles, and metals.

This classification was put forward by the great Werner himself, that “Socrates of mineralogy,” as the Italians called him. Not that before his epoch no digressions had been adventured. To certain stones influences fav-

ourable or inauspicious had been attributed. Some, it was said, counteracted the glance of the *mal'occhio*, or evil eye; others warded off, or drew down, the thunderbolt; others rendered Venus propitious, or the reverse. The classification of minerals into "noble" and "worthless" reminds us of the alchemists, and brings back to our memory the division Theophrastus sought to establish of stones into "males" and "females;" reserving, it is true, to the latter the finest qualities, those of beauty, colour, and brilliancy.

Nevertheless, up to the close of the last century the world remained ignorant of lithology.

It imagined that stones *grew*; it believed in a lapidific juice; in a word, it resuscitated the idea of Democritus, that Greek philosopher who was continually laughing, and who, undoubtedly for the sake of carrying on the jest, attributed to stones a vegetative existence. In this belief, if not in the life of stones, both Tournefort and Linnæus shared, as Aristotle had anciently done. Other men of science pushed their theories even further. They asserted that stones sprung from germs, like plants, and declared they had discovered not only the seeds, but also the flowers of coral. There are people who still cherish these fanciful ideas. Jewellers speak seriously of the lapidific (or stone-creating) juices; and pseudo-archæologists assure us that it is owing to this growth of stones that the Roman Forum and the temples of Egypt and Assyria are now sunken several yards below the surface of the soil!

But let us put aside these theories, which are more

brilliant than solid ; these poetic vagaries, which wander too far from the truth. In the course of the preceding pages we have already indicated the true origin of rocks, and have shown that they are produced by the action either of water or fire, those two great primeval elements to which the formation of the globe itself is due. Minerals compose its crust, or rind ; and the principle of life embodying itself in them has given birth to the organic bodies, to plants and animals.

This rapid glance at the wide domain of natural philosophy must here suffice. In the grand problem of life there are still so many difficulties to resolve, that the moment has not arrived for attacking these formidable questions. Let us return to our pebbles and our minerals, and let us walk humbly ; it is the safest way of avoiding a disastrous fall !

The earths, the stones, the salts, the combustibles, and the metals, to which we must join, in order to complete our nomenclature, the liquids and the gases,—these are the seven principal divisions of the great mineral kingdom. The reader has already made acquaintance with three, at least in part : with fossil carbon or coal, among the combustibles ; sandstones, limestones, and the like, among the rocks ; and, finally, with the metals. We have still to notice the earths, the salts, the liquids, and the gases.

Strictly speaking, the salts are included among the earths. Foremost in their rank we place *the salt par excellence*,—rock-salt, common salt ; but the most im-

portant of the earths is the vegetable earth, the all-bountiful nurse of humanity. This is composed of various elements, proceeding mainly from disintegrated rocks. Clay, which has given birth to the potter's art, is also an earth, the usefulness of which cannot be overestimated.

In their turn, the liquids and the gases play, in the economy of this world, a far more important rôle than one would at first suppose to be the case. The primary liquid is water, which the well-sinker, if it cannot be found in springs and streams, seeks beneath the surface, just as the miner seeks for coal. And forth it leaps, in sparkling Artesian jets, which fertilize the fields, refresh and feed the cities, and supply many of our mills and great industrial works with their motive power.

Nor yet are these all the services rendered to us by the subterranean waters. The medicinal value of mineral-springs is now very widely acknowledged.

The natural gases, pumped up from the entrails of the earth, bring with them heat ; nay, more, bring with them light, as we see in several countries, and more particularly in China. Sometimes they are rich in peculiar substances, which are of the highest value in our industries : such are the *fumeroles* of boric (or boracic) acid in Tuscany.

Our limits will not allow us to dwell at any length on the study of the earths and salts, the liquids and natural gases. But I cannot pass over in silence some interesting workings which may justly lay claim to be included among the wonders of the subterranean world. Who has



SALT-MINES OF BOCHNIA, GALLICIA.

not heard, for example, of the salt-pits of Bochnia and Wieliczka, in Galicia? Who has not heard of the *soffioni* or *fumeroles* of boracic acid in Tuscany?

Much, nay, too much, has been said in reference to the remarkable salt-pits of Wieliczka and Bochnia. Travelers have told us of families of miners who had lived there underground for centuries—had been born there, had died there; of houses, churches, and hotels, forming a city of the shadows; of streams of fresh water which flowed by the side of brackish currents; and, finally, of a windmill, whose sails incessantly plied their laborious task in the profound abyss. In all these stories there was not a word of truth. Yet it is true enough that these rich salt-mines are the most interesting in the world. It is said that in the interior canals have been excavated for the transport of the salt, like those which are used for the transport of coal in the coal-mines of England and Prussia. In the solid salt are also wrought numerous statues and chapels. On several occasions the German princes have visited these singular deposits, and fêtes and balls have been given in their honour, and even pyrotechnical displays. We are narrating facts, and the facts are curious enough to be worth recording.

We now turn to the salt-mines of Tuscany, which from the time of the Medicis until the formation of the new kingdom of Italy belonged to the Tuscan crown. The construction of the present works dates from the reign of Pietro-Leopold, the great reformer, who had the glory of



CHAPEL OF ST. ANTHONY, SALT-MINE OF WIELICZKA, GALLICIA.

introducing peacefully into his little state those reforms and ameliorations which larger states have secured at the cost of a revolution.

The works, successively enlarged by the successor of Pietro-Leopold and by the last Grand Duke, contained four immense concentrating boilers, and two for crystallization; the whole being arranged under an immense roof, and in the heart of a colossal establishment. The quantity of salt produced is estimated at upwards of 26,400 pounds daily. The crystals are snowy white, perfectly dry, and the purest and most beautiful it is possible to imagine. In fact, none are to be compared to them, except those which are produced by the celebrated Nanteviel salt-erns.

The waters whence the crystals of Val-di-Cecina are obtained traverse strata of saliferous clays, which are locally called *moje*, and are situated at a tolerable depth below the surface.

These waters are pumped up in the same way as in Artesian wells. The deposits lie at some distance from the works.

Wooden troughs conduct the saline solutions into a vast reservoir; thence they flow into the evaporators, and, finally, into the crystallizers, where the product is deposited.

The clays which contain the salt generally inclose it in the microscopic state; and it is probable that they owe their peculiar composition to the salt waters in the midst of which they were deposited at the epoch of their geological formation.

As we are speaking of mineral salts in general, we may here refer to the alum-beds at Tolfa, about six

miles from Civita Vecchia ;* and to those still worked on so large a scale at Montioni, in the Tuscan Maremma.

The Montioni quarries are very ancient. They were wrought with much activity throughout the Middle Ages. As well as many others, they belonged to the neighbouring republic of Massa Marittima, which sold the alum to Florence. There it was used as a mordant in dyeing woollen stuffs—*l'arte della lana*, as it was named. It was this industry which contributed so largely to the renown of that great city, and was the principal source of the wealth of its famous merchant-princes.

Under the Grand Dukes of the Medicis dynasty, the quarries of Montioni continued to be worked, but with the freedom of the Florentines disappeared their riches, their industrial energies, and commercial enterprise. Nevertheless, Cosmo I. derived a large revenue from the alum-mines of Tuscany, not only from those of Montioni, but also from those of Campiglia. The direction of the latter he entrusted to a master-workman, whom he procured expressly from Tolfa. The quarries of Tolfa were then, and are now, the most famous in Italy. Their products are exported to every part of the world ; but the quantity extracted has diminished since other chemical agents, such as the sulphate of zinc and alumina, have to a considerable extent replaced alum as a mordant for fixing colours.

The active and energetic resumption of the works at Montioni is due to the Princess Elisa Bacciochi, who

* The first alum-works in Europe are said to have been established here in 1460.

reigned as Grand Duchess of Tuscany during the short-lived empire of Napoleon I. ; and to a Frenchman, M. Porte, who had accompanied her into her principality of Piombino. Since that epoch the works have not been interrupted. They are well worth a visit. The surrounding soil presents a volcanic appearance, owing to the ancient thermal, alkaline, and sulphureous springs which have furrowed the surface, and also to the gaseous emanations which incessantly rise through the fissures in the adjacent rocks. There remains, as a testimony to the geological phenomena which occurred in some far-off age, a warm sulphureous spring, where baths have been established for the use of the inhabitants of the neighbourhood.

Near Tolfa, in like manner, is Stigliano, a place held in high repute by the Romans for its mineral waters. The modern name is corrupted from *Stygianum Vicus*, a place on the ancient Via Claudia. The hot springs here are of great efficacy in eruptive diseases, in nervous and scrofulous affections, rheumatism, and paralysis. They are five in number : two for bathing, and three for drinking. The temperature of one, the *Bagno Grande*, varies from 95° to 104° F. ; of the Bagnarello, from 140° to 158°. The waters contain sulphates, carbonates, and muriates of lime, magnesia, soda, and iron, with salts of ammonia and iodine in smaller proportions, and sulphuretted hydrogen gas.

The action of the waters and gases of which we have spoken has considerably modified the nature of the soil

which they have traversed, and transformed into alum-stones the aluminous schists of Montioni. Thus the configuration of the soil, at the points where the rock is bare, presents itself to the eye of the geologist in an advanced state of *metamorphism*. It seems to be no longer a sedimentary, but a volcanic formation. The boundary lines which mark off the strata of the Neptunian rocks are no longer apparent, and the working of the quarries is carried on without any system. The quarrymen use their picks at random, and judge of the greater or lesser richness of the ore from the appearance of the alum-stone. The result of this mode of working has been to produce here and there enormous and even terrific chasms, which seem, as it were, in many places, to be their own support. However, they communicate naturally with the surface, and the quarrymen descend into the depths of these huge caverns either by the aid of a rope coiled round a windlass, or by steps cut in the rock which make the circuit of the entire excavation. No prop, pillar, or balustrade has been constructed, and the visitor who ventures upon the descent need be free from all symptoms of vertigo !

We borrow from M. Simonin some details of his excursion to the quarries. He found, he says, the superintendent, or manager, whom the Grand Duke Leopold had installed at Montioni, priding himself on the progress the works had made. Notwithstanding the strong opposition of the *reggio consultore*, or royal councillor—a German engineer whom the Grand Duke, in his partiality for the Austrians, had imported from Freyberg—he had abolished to some extent the barbarous system of working which we have described, and adopted the modern system of shafts and galleries. He was not then at the quarries, but was enjoying his *estatura*, or summer

holidays, in order to escape the fevers of the pestiferous Maremma. But one day, says Simonin, when, passing near the alum-pits, I turned aside from my road to visit them, he showed an evident pride and pleasure in personally conducting me over the works. He had at length found a man to whom he could develop his ideas ! I belonged, one may say, to the same profession, and he conducted me to his finest gallery. He had previously given the necessary instructions, and the entire length, straight as a railway tunnel, and of dimensions almost as considerable, was lighted up with candles, as if in honour of a grand-ducal visit. We entered the gallery sweating with the long and toilsome journey we had made through the surface quarries. The director gave me not a moment's respite, that he might the sooner enjoy his triumph. Partly out of politeness, and partly in consideration of my professional character, I did not dare to make any observation. I therefore entered the tunnel bravely, at the risk of catching the fever by passing suddenly, and while perspiring profusely, from the hot air without to the chill damp atmosphere of the gallery. It is in these circumstances that the fever of the Maremma loves to seize upon you, attacking its victim suddenly and when he is off his guard.

The tunnel glittered with radiance, and my conductor beamed with joy. We soon arrived, by a tolerably long detour, in which our lamps were our only guides, at the bottom of an immense excavation. Here was established the blasting apparatus. The miners had received due notice, and three simultaneous discharges sent the rock flying in a myriad fragments. But the usual precautions had not been taken ; the air, suddenly driven back into the galleries, rushed through the tunnel to find an outlet, and extinguished all our lights, so that we durst not venture to return the way we had come. We maintained a good heart, however, against our ill luck, and adopted the shortest road back, though not the most convenient. Clinging to the rope of the shaft, we made our appearance at the foot of the windlass, to the great astonishment of the workmen. My guide uttered not a word. He could scarcely digest his mishap. He was not unnaturally furious at so unfortunate a denouement after so splendid an opening. However, he gradually recovered himself, and attended me on a visit to the furnaces where the alum is calcined, which are not unlike lime-kilns. Thence we passed on to

the dissolving and condensing pans, and finally to the crystallizing chamber. Here I admired at leisure the curious phenomenon in virtue of which the alum crystals gather in clusters round any article—a wire, a stick, a piece of thread—thrown into the reservoir into which the solution is poured. I visited also the storerooms where the crystals are dried and packed. The manager showed me with much pride the remarkable fineness and whiteness of his products; he boasted of his wares, to the excellent fabrication of which he had undoubtedly contributed very largely. He told me that the works turned out one hundred and fifty tons per annum; and he added that his alum was more highly esteemed in commerce, and fetched a higher price, than that of Rome. I did not enter into any discussion thereupon, partly from a feeling of incompetency, and partly because the dinner-hour had arrived. I gladly accepted the hospitable manager's invitation to share in his family repast; and in the afternoon of the day so well and busily spent, I left Montioni with a satisfied mind and a contented heart.

While referring to the subterranean wealth of Tuscany, we must not forget to describe its famous *soffioni*, or natural jets of boracic acid vapour, to which, indeed, we have already alluded.

These jets of hot vapour, these *soffioni*, escape from the earth with a loud report, and are now utilized on account of the boracic acid which they contain. Around the sites of these volcanic phenomena the soil is completely denuded, completely barren, and incapable of cultivation, on account of its excessive heat. The earth gapes with chinks and crevices; and from these, at short intervals, escape tiny columns and clouds of spray, more or less visible according to its degree of condensation, and gathering upon the surface of the soil when the weather is damp. By the presence of some or all of



MONTÉ CENROLI IN 1812.

these signs the locality of the *soffioni* or *fumeroles* is easily detected.*

Where the vapours are most abundant, and where the ground is worked, the configuration of the latter is not unlike that of a crater. Moreover, the rock is modified to a very large extent by the disengagement of vapour and gas ; it disintegrates and crumbles into dust. Among other substances, alum and crystals of sulphur are found there ; these were formerly utilized, but at present they are entirely wasted. The attention of the workmen and their employers is concentrated upon the boracic acid, the extraction of which is very profitable, and for which there is always a good market. This material (if we may so term it) is evolved in the gases of the *soffioni*, combined with the aqueous vapour they throw off in such abundance. Among the other gases we may name sulphuretted hydrogen as being largely present ; it is easily recognized by its odour of rotten eggs. Here we may note that this gas apparently exercises no deleterious influence upon the health of the workmen. It is more easy to explain its action in the neighbouring vineyards, which it preserves from the plague of the oidium.

Boric or boracic acid was first discovered in the *sof-*

* "As you approach the lagoons, the earth seems to pour out boiling water, as if from volcanoes of various sizes, in a variety of soils, but chiefly of chalk and sand. The heat in the immediate neighbourhood is intolerable, and you are drenched by the vapour, which impregnates the atmosphere with a strong and somewhat sulphureous smell. The whole scene is one of terrible violence and confusion: the noisy outbreak of the boiling element, the rugged and agitated surface, the volumes of vapour, the impregnated atmosphere, the rush of waters among bleak and solitary mountains. The ground, which burns and shakes beneath your feet, is covered with beautiful crystallizations of sulphur and other minerals; its character beneath the surface at Monte Cerboli is that of a black marl, streaked with chalk, giving it at a short distance the appearance of variegated marble."—*Dr. Bowring*.

fioni of Monte Rotondo, in the Tuscan Maremma, about 1777. Previously the *fumeroles* had been regarded simply as natural curiosities. They are mentioned by Lucretius; who, however, had no conception of their industrial value. It was left for modern chemistry to discover the useful and important substance which they contain, and the presence of which was detected by Hœffer, apothecary to the Grand Duke, through the specific property it possesses of communicating a green colour to the flame of alcohol.

As soon as its existence was recognized, an attempt was made to extract it by transmitting the vapours through water, in which they abandoned the boracic acid, leaving it in a state of solution. The basins constructed for this purpose, and named *lagoni*, or little lakes, were arranged in tiers, one above another, and the operation was carried through all of them in due succession, in order to secure the concentration of the acid. Mascagni, the eminent naturalist, who commenced these experiments, conceived the idea of utilizing the natural heat of the sources as a kind of *bain-marie* to evaporate the lye. But his attempt proved a failure.

About 1816, a French merchant of Leghorn, M. Larderel, resolved to resume the experiments, and a company was formed. Three factories were erected, one of which was at Monte Rotondo. As the waters heated by the *fumeroles* did not possess sufficient caloric power to evaporate the lye, wood was made use of; but this fuel is costly in Tuscany, and in 1827 the new enterprise was given up.

The proprietors were greatly discouraged. M. Lar-

derel alone, endowed with a very uncommon share of faith and energy, resolved upon carrying the project to a successful issue, and for this purpose he indemnified his associates. Success crowned his protracted efforts; he literally imprisoned the vapours of the *soffioni*, and conducted them to the distilling basins. As at the point of emergence some of these vapours possess the temperature of boiling water, the reader will understand that thenceforth the evaporation of the lye and the crystallization of the boracic acid could be effected at a comparatively trivial expense. So the production went on increasing, and a few years ago M. Larderel owned ten flourishing establishments, which annually yielded upwards of 3,000,000 pounds Tuscan. The works are now in the hands of an English company, whose profits are understood to be very great. Upwards of 1200 pounds of water are evaporated daily.

The collection of boracic acid extends, at present, over an area of thirty miles. The plan adopted is to form a series of lagoons, from one hundred to one thousand feet in circumference, and seven to twenty feet in depth, partly by excavation, and partly by building in the side of the volcanic mountain, where the steam and acid are evolved through countless fissures, and then to divert the course of a mountain stream, so that at any moment the *lagoni* may be supplied with water. As the vapours of the *soffioni* pass through the water of these lagoons, the boracic acid is arrested by the water, which takes up $1\frac{1}{2}$ to 2 per cent. of it. The liquid passes from one basin to another; then into settling vats and flat-bottomed evaporating pans, until the solution is suffi-

ciently concentrated, when it is conveyed into wooden cooling-vessels, where it is left to cool, and to deposit crystals of boracic acid.

Needless to say that the appearance of the scene, with thousands of jets of vapour issuing from the ground, is very impressive; and the name given to one of the principal mountains, *Mons Cerberi*, or *Monte Cerboli*, would seem to indicate the superstitious terror by which the mind of the neighbouring peasantry was formerly affected.

Boracic acid is found also as a saline incrustation in the crater of a mountain in the island Volcano—the ancient Hierā—situated about twelve geographical miles to the north of Sicily.* The crater is about seven hundred feet in depth, and the sides are covered with a layer of boracic acid about half an inch thick, yielding an annual supply of 2000 tons.

Boracic acid (BO_3) occurs in feathery crystals of a yellowish white. It is used in the arts as a flux, and as an ingredient in the glaze employed in pottery, and in the manufacture of paste for artificial gems. Moreover, the wicks of composite and stearine candles are treated with it, so that when the candle is burning the end of the wick may fuse and be thoroughly consumed.

It is also valuable as yielding borax ($\text{Na O}, 2 \text{BO}_3$) or baborate of soda, a substance of the highest utility in the chemical arts. With the various metallic oxides it forms coloured glasses of great beauty—such as emerald green with oxide of chrome, and an intense blue with oxide of cobalt; and it is useful as a flux in soldering copper and iron and the precious metals.

* It occurs also in Thibet and South America.

M. Simonin describes a visit which he paid to the great boracic acid works situated in the plain at the foot of Monte Rotondo. He says that within their precincts is included a sulphureous lake not unworthy of comparison with that of Avernus. Its waters present a yellowish soapy look, and at intervals, by the ebullition which takes place on the surface, the spectator detects the localities of the *soffioni*.

A small boat, stranded on the muddy and reedy shore, enabled me, says Simonin, to make an excursion on the water. The banks rose from the margin of the lake in such wise as to imitate a crater, of which the lake represented the bottom. There was nothing attractive in the surrounding landscape, and the skiff in which I had embarked reminded me of Charon's ferry-boat. When I had finished my excursion, the boatman did not ask me for my *obolus*, and it was by this sign only that I found I was not on the banks of the river Styx.

All around the lake, the *soffioni* made a frightful uproar. Some years ago, the manager conceived the happy idea of *sounding*, so to speak, for the subterranean vents; and he was thus enabled to demonstrate that *veins* or ducts of vapour traversed the sub-soil of these localities, just as we meet with channels of water at other points.

When the workmen reached the *soffioni*, the vapours escaped with a rush through the outlet opened for them. Arriving at the surface with a great din, they projected to a considerable height the stones and mud and clay which, in their upward passage, they had disrupted from the sides of the vent. All this *débris* afterwards fell back upon the soil, to the great terror of the shaft-borers, who protected themselves as best they could. It was the image, on a miniature scale, of a volcanic eruption, but without the flame, or, more strictly speaking, the incandescence. One of these shafts, opened in the preceding year, had brought to the light of day a *soffioni* of so much power that the hissing of the vapour was audible for leagues around; it was like a dozen locomotives letting off steam simultaneously. So strong was the jet, that it could not be confined and conducted into the caldrons. It became necessary to fill up and abandon the artificial vent.

If the *soffioni* contained no gas injurious in its action upon metals,

as, for instance, sulphuretted hydrogen, it is clear that, under certain conditions, they would furnish, besides their stock of caloric, a reservoir of mechanic force which might be advantageously utilized. It is in this way that the Chinese effect sounding-holes, or sink shafts, to draw from the earth its illuminating gas; and that in the United States—in Ohio and Pennsylvania, for example—wells have recently been sunk for the extraction of mineral oil and the carburetted hydrogens (petroleum).

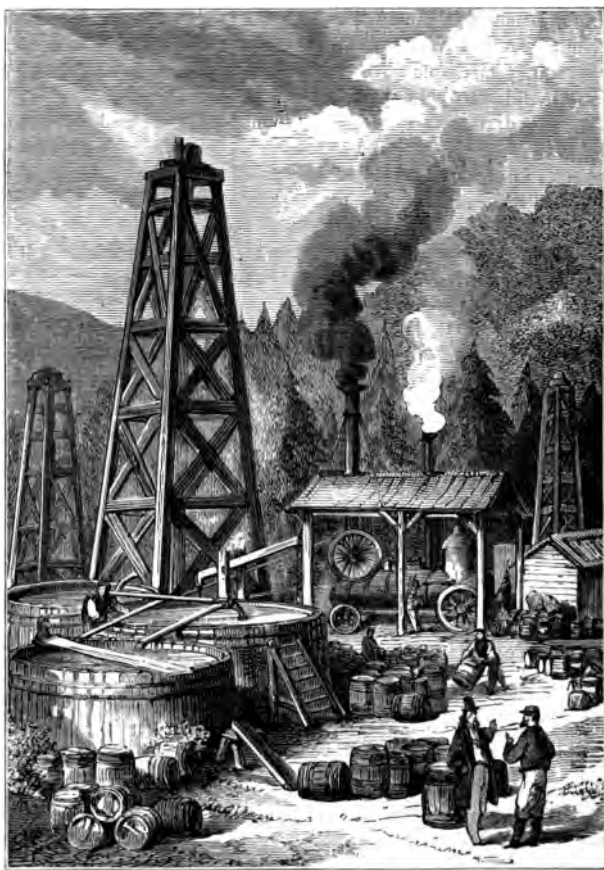
The depth at which the vapours of the *soffioni* are met with is not sufficiently considerable to explain their high temperature. It is known that the heat increases at the ratio of 1° C. for every 35 to 40 yards beneath the surface, and therefore it is not until we reach a depth of 10,500 to 11,000 feet that we meet with the temperature of boiling water (or 100°). But the shafts of Monte Rotondo never attain to 325 feet. It is probable, therefore, that the *soffioni* proceed from a lower furnace, or that their temperature is owing to certain electrical and chemical phenomena of which we have no very accurate idea.

We quote again from M. Simonin :—

Desirous of visiting the various establishments of M. Larderel, that I might perfect and complete my study of this strange phenomenon of the *soffioni*, which until recently Tuscany alone presented, though it has since been discovered in California, I took leave of my amiable hosts of Monte Rotondo. They would fain have detained me longer, but science prevailed over friendship.

All along the road, as far as the central establishment of Monte Cerboli, which is named *Larderello* in honour of its founder, we traversed a series of *soffioni*. At intervals we came upon large and thriving works, notably at Sasso, Lustignano, Serrazzano; then came Castelnovo and Monte Cerboli—the two latter lying close to the road.

The peculiar appearance of these works, their perforated domes of masonry arching over the imprisoned *soffioni*; the troughs, partly suspended in the air, which conduct the jets into the lagoons; at other points, the terraced basins or the ancient *lagoni*; and, finally, the evaporating pans and cooling-vessels, all in full activity, in which



PETROLEUM WORKS OF TAR FARM, PENNSYLVANIA.

the waters were evaporated and precipitated their crystals ; the warm chambers for drying the acid crystals ; here, there, and everywhere a pungent odour of sulphureous gas and driving clouds of aqueous

vapour sufficient to blind an army of visitors ;—this interesting spectacle would have overwhelmed me with astonishment if I had not been already initiated, on my visit to Monte Rotondo, in the different details of a very curious industry.

From the general geological study to which I devoted my time in this excursion, I discovered that all the *soffioni* are arranged upon or near a line which strikes perceptibly from S.S.E. to N.N.W.

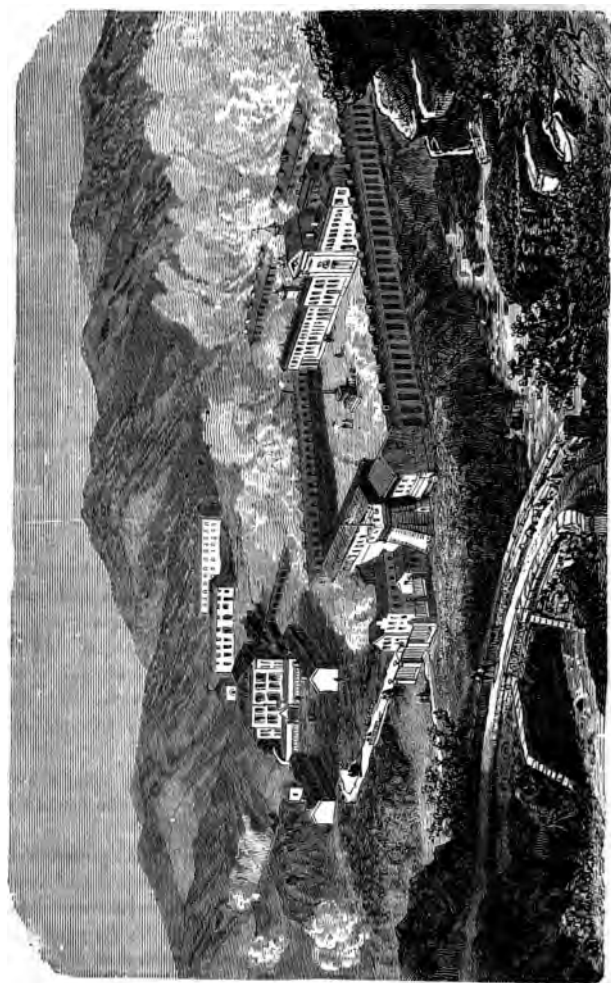
The formation of these *soffioni* is connected with the upheaval of the metalliferous chain which traverses the Tuscan Maremma in that direction, and with the appearance of eruptive masses, such as the serpentine and other green rocks, which have produced this upheaval. These rocks have opened fissures in the soil through which the *soffioni*, issuing from a common subterranean furnace, have risen to the surface.

The establishment of Larderello, where I remained for some time, is a kind of central factory ; a small operatives' village, with its open square, its statue, and its fountain, its priest, its physician, and its druggist.

The workmen of the establishment and the poor people of the neighbourhood receive gratuitously both medical advice and medicines ; but M. Larderel has not only provided for the health of the souls and bodies of those dependent upon him, but has also taken care of their minds, having founded in his little town a children's asylum and a school of music. He has also erected weaving-looms for the widows and sisters of the workmen. And lastly, a kind of Benefit Society, which makes weekly allowances to widows, aged men, and orphans, is in regular operation at Larderello. All the other establishments enjoy the benefits of a similarly paternal administration.

M. Larderel, who died a few years ago, was the founder and creator of his own fortune, and the father of the important industry of boracic acid, one of the most curious in Europe.

Before his time, borax (or biborate of soda) was imported at a great cost from India and Egypt. The sudden decrease of price has been due to the Tuscan manufacture ; and the prices would have been still lower, but for the agreements by which M. Larderel was fettered. At all events, thanks to the introduction of this new industry, a country formerly savage, desolate, and barren, has been



MONTE CERBOLI (LARDERELLO) IN 1853

transformed into a country prosperous, animated, and well-peopled. In exchange for a little smoke, which formerly was lost in the air, the manufacturer of boracic acid has enriched Tuscany to the extent of £60,000 per annum; I say Tuscany, for M. Larderel, not content with supporting a legion of workmen in his factories, has liberally spent all that he has gained, and sunk millions as well in his Leghorn palace as in his vast estates of Pomarance.

At Larderello, which he founded, and which he took a pleasure in embellishing, the first thing that attracts the eye is the pleasant, open square so appropriately designated the *Piazza della Industria*.

On one side of this area are situated the chemical laboratory, the mineralogical museum, the pharmaceutical stores, the philharmonic or music school, the boys' and girls' schools, and the weaving room for women. In the centre stands the church, whose incumbent joins to his spiritual duties those of the schoolmaster. Next comes the hospital, to which a physician is attached. On the other side of the square rises the palace formerly occupied by M. Larderel.

Nothing was wanting to complete the appointments of this splendid mansion; not even a theatre, whose actors were selected from the most intelligent workmen. The able and honest merchant-prince who made so noble a use of his wealth had received successively from all the princes of Europe the rewards which he merited. The Grand Duke was the first to decorate and ennoble him. The Comte de Larderel of Monte Cerboli, in grateful recollection of the *lagoni*, the source of his immense riches, took for his crest a *soffione* escaping from the soil like the smoke-shaft of a crater.

This eloquent device, this novel kind of blazonry, procured him the nickname of "Count Fumo" from idle wits incapable of appreciating a noble self-confidence; but he was proud of his brilliantly successful career and of the honours heaped upon him.

He took an innocent pleasure in displaying his decorations; and I have seen at Monte Cerboli, in a saloon running parallel to the chemical laboratory, in the midst of a magnificently gilded framework, all the crosses and ribbons which Europe can bestow. The overseer of the works conducted the visitor religiously into this saloon, after showing him the *lagoni*; it was, as it were, a final bouquet! Let us add that M. Larderel's noble qualities might well

purchase forgiveness for his little manifestation of vanity ; no man can arrive at the high fortune which he attained, unless endowed with high intellectual gifts.

Does the reader remember the famous description in Lucretius of the Lake of Avernus ? If not, he will be glad to listen again to the stately march of these noble verses :—

“ Nunc age, Averno tibi quæ sint loca cumque lacusque,
 Expediam ; quali natura prædita constant.
 Principio, quod Averno vocantur, nomen id ab re
 Impositum est, quia sunt avibus contraria cunctis,
 E regione ea quod loca cum advenere volantes,
 Remigii oblitæ pennarum vela remittunt,
 Præcipitisque cadunt molli cervice profusæ
 In terram, si forte ita fert natura locorum ;
 Aut in aquam, sic forte lacus substratus Averno est.
 Qualis apud Cumas locus est montemque Vesevum,
 Oppleti calidis ubi fumant fontibus auctus.”

Thus translated by Creech :—

“ Next of Avernus sing, and whence the name,
 And whence the rage, and hurtful nature came.
 So called, because the birds that cut the sky,
 If o'er these places they but chance to fly,
 By noxious streams oppressed, fall down, and die :
 Death meets them in the air, and strikes them dead ;
 They fall with hanging wing, and bended head ;
 And strike the poisonous lake or deadly field :
 Such vapours boiling springs near Cumæ yield.”

The description given by Virgil resembles the above in its leading details :—

“ Before his eyes a monstrous cave
 Expands its yawning womb,
 Protected by the lake's dark wave
 And forest's leafy gloom :
 O'er that dread space no flying thing
 Unjeopardied could ply its wing ;
 Such noisome exhalations rise
 From out its darkness to the skies.”

This famous lake (*Lago d'Averno*) is situated in the province of Naples, between the ancient Cumæ and the translucent waves of

the Gulf of Baïæ. It is described as occupying the crater of an extinct volcano, whose steep acclivities, rising abruptly round it, were formerly covered with dark, dense woods, which gave it a singular aspect of gloomy terror. It was this circumstance, probably, and the mephitic sulphureous exhalations which abound in the vicinity, that induced the lively fancy of the Greeks to fix upon it as the entrance to the Lower World, and as the scene of the visit of Odysseus to the realms of Pluto. The old belief was, that the pestilential vapours springing from its dark waters were so deadly in character that no animal could breathe of them and live, and that they struck down the birds which attempted to wing their way across the lake as surely as if they had been pierced by the marksman's arrow. Hence its Greek name "*Αἰπρος*" was generally supposed to be derived from *ἀ* and *ἔρως* ("without a bird"). It may very well be that this was a mere etymological fancy, yet for the statement itself we are inclined to think that some foundation existed. It is known that similar effects from mephitic exhalations occur in the valley of Amsanctus and other localities; and it is to be noted that Virgil, whose description we have quoted, does not represent the vapours as issuing from the lake itself, but from a hollow in the adjacent rocks. Both Virgil and Lucretius use the expression "*Averna loca*," showing that they do not refer to the lake so much as to the surrounding district. It has been suggested that, in the old times, the lake was densely surrounded with forest-growth, and that this would so obstruct the free circulation of the air as to render the whole atmosphere more or less pestilential. There is every reason to believe, moreover, that the volcanic action was then more powerful than it has proved since the days of Strabo. The vast engineering works of Agrippa, by which he designed to unite Avernus and the Lucrine with the sea, also assisted in dispelling the terrors of the scene. The forests were felled; the ground was cleared. An army of slaves, twenty thousand strong, was employed to cut a canal through the tract which lay between Avernus and the Lucrine, and another through the narrow belt of sand which divided the Lucrine from the waters of Baïæ. The effect of these operations was to reduce the level of Avernus to that of the Mediterranean, and to convert the two lakes into a port—*Portus Julius*—while restoring the climate to a condition of salubrity.

Such engineering enterprise was then uncommon, and Virgil thought it worthy of commemoration in his *Georgics* :—

“ Or shall I praise thy ports, or mention make
Of the vast mound that binds the Lucrine lake ;
Or the disdainful sea that, shut from thence,
Roars round the structure, and invades the fence ;
There, where secure the Julian waters glide,
Or where Avernus’ jaws admit the Tyrrhene tide ? ”

The new port was of such magnitude that the whole Roman fleet could manœuvre in its double basin ; but if Strabo may be credited, Avernus was not much used, the Lucrine being more convenient, from its proximity to the sea.

It was upon these lakes that Agrippa gave his celebrated representation of the sea-fight off Actium, in the presence of its hero, the Emperor Augustus.

Up to the sixteenth century the canals, and the piers at the mouth of the port, were in a perfect condition ; but the great eruption of Monte Nuovo in 1538 destroyed the communication, filled up half the Lucrine, and brought about so great a change in the relative levels of the sea and land that the port disappeared. At present, the belt between the lakes is thickly covered with brushwood and fragrant myrtles, among whose verdure may here and there be seen some time-worn masses of masonry, in which are plainly visible the holes for the rings that secured the mooring-cables.

The Lake of Avernus measures about a mile and a half in circumference. It was anciently believed to be unfathomable, but its depth nowhere exceeds 250 feet. On the south it is open to the Lucrine and the Bay of Baiæ ; on the east, west, and north it lies embosomed among hills which now are green with groves of chestnut and prosperous vineyards. Its fresh waters teem with fish, and it is visited in winter by various species of aquatic fowl. How changed the scene since the epoch when Homer fixed upon it as the site of the threshold of Hades :—

“ Soon shalt thou reach old Ocean’s utmost ends,
Where to the main the shelving shore descends ;
The barren trees of Proserpine’s black woods,
Poplars and willows trembling o’er the floods :

There fix thy vessel in the lovely bay,
And enter then the kingdoms void of day ;
Where Phlegethon's loud torrents, rushing down,
Hiss in the flowing gulf of Acheron ;
Cocytus' lamentable waters spread ;
Where the dark rock o'erhangs the infernal lake,
And mingling streams eternal murmurs wake."

From a remote antiquity there existed an oracle or sanctuary on the banks of the Avernus, connected with the sources of the pestilential gases, of which the attendant priests seem to have made use in their ceremonies. Many writers asserted that it indicated the exact spot where Odysseus conferred with the shades of the departed. They pretended that the "Cimmerii" of Homer were the people who anciently lived in these sunless wildernesses, and the poet's statement that they never saw the orb of day was explained as referring to their residence in subterranean abodes and caverns hollowed in the rocks. The oracle continued to flourish to a comparatively late period, and the lake was looked upon as sacred to Proserpine or Hecate, to whom sacrifices were frequently offered. It was to share in these sacrificial rites, or, as Livy hints, to pay a mock reverence to the *dura religio loci* while he secretly reconnoitred the defences of Puteoli, that Hannibal, in B.C. 204, visited the Lake Avernus at the head of his army.

We turn now to the Lake of Agnano, which lies about six miles from Naples, and, like the Avernus, was undoubtedly at one time the crater of a volcano. The strata, says Dr. Daubeny, whose edges are visible in its interior, instead of having a corresponding dip on the opposite sides of the cavity, as is commonly the case with valleys formed by diluvial action, seem, on the contrary, to slope in all directions away from the centre, just as would happen if the strata had been thrown up by a force acting from below.

The lake is nearly three miles in circumference, and is

characterized by a remarkable but picturesque irregularity of outline. Though its banks are clothed with verdure and diversified by gently-swelling hills, and though its waters generally swarm with aquatic birds, yet the lake is a constant source of malaria, owing to its exhalations of warm vapour impregnated with sulphuretted hydrogen. As neither the lake nor the crater which contains it is described by any writer of antiquity, we may suppose that the whole district has undergone very considerable changes since the Roman period.

On its south-east bank occur some ancient chambers—the *Stufa di San Germano*—in which the hot sulphureous vapour, issuing from “beneath the surface” at the temperature of 180° F., is collected for the benefit of rheumatic and gouty invalids. The name of the *Stufa* perpetuates the vision of St. Germanus, Bishop of Capua, in the sixth century, which is related by St. Gregory the Great in his “Dialogues.”

About one hundred paces from the *Stufa*, and at the base of the hill, is situated the opening of the celebrated *Grotta del Cane*, or Cavern of the Dog.

It was known to the ancients as the *Spiracula* or *Scrobes Charoneæ*. Pliny refers to it in Book ii. c. 93 :—“Et locus in Puteolio lethalem spiritum exhalans.” Its modern name is due to the circumstance that the pernicious effects of its vapours are usually tested upon dogs. It must be remembered, however, that they are not less fatal to other living beings who may accidentally or intentionally be exposed to their influence. Charles VIII., King of France, it is said, made an experiment on an

GROTTA DEL CANE.



ass. Cluverius asserts that the grotto was once used as a place of execution for Turkish captives, who were immured within its recesses, and left to die of suffocation. A couple of slaves were exposed to the same fate by Don Pedro de Toledo, Viceroy of Naples, and we are told that they died in ten minutes.

About the appearance of the cavern, which is of small dimensions, there is nothing remarkable. It measures about five feet in height, two feet in depth, and three feet or more in width, and resembles a small cellar rudely excavated in the tufa.

From the bottom of the cavern rises a hot, thin, subtle, but clearly perceptible vapour ; not in tiny jets, but in a continual stream, which covers the entire surface of the flooring of the grotto ; and whose density, being superior to that of the atmosphere, keeps it accumulated near the ground. This vapour is composed of carbonic acid gas, mixed with water.

The level to which the vapour rises is indicated by the colouring of the sides of the cavern. This is a deep green as high as the gas ascends, and of a dull brown earthy tint above. The sensation, says Dr. Daubeny, which I experienced on stooping my head for a moment to the bottom resembled that of which we are sometimes sensible on drinking a large glass of soda-water in a state of brisk effervescence. The cause in both instances is, of course, identical.

The quantity of carbonic acid present in the cavern at various heights was shown by immersing in it various combustibles in a state of inflammation. Dr. Daubeny found that phosphorus would continue lighted at about

two feet from the bottom, while a sulphur match went out a few inches above, and a wax taper at a still higher level.

It is impossible to discharge a pistol at the bottom of the cavern, for though gunpowder may be exploded even in carbonic acid by the application of a heat sufficient to decompose the nitre, and consequently to envelop the mass in an atmosphere of oxygen gas, yet the mere influence of a spark from steel produces too slight an augmentation of temperature for this purpose.

These and other experiments were first tried by Addison. Their *rationale* is, of course, sufficiently obvious.

About midway between the Lake of Agnano and Pozzuoli the traveller's attention is directed to the *Solfatara*, a semi-extinct volcano of high geological interest. It now forms an oval but irregular plain, partly inclosed by broken hills of pumiceous tufa, which formed the walls of the original crater. A mass of trachyte in the centre has been forced through the stratified tufa. As the surface, when struck, gives forth a hollow sound, it has been conjectured that the crater forms a large vaulted chasm underneath the present floor. From some of the chinks and fissures steam and mephitic gases are continually being exhaled. These chinks and fissures are known as *fumeroles* or *fumaroli*, and the gases they emit consist of sulphuretted hydrogen and a minute portion of muriatic acid. Sulphur, alum, and sulphate of iron, occur in the crevices of the rocks.

Strabo describes the Solfatara under the name of the Ἡφαίστου Ἀγορὰ, or *Forum Vulcani*; and states, on the

authority of Pindar and Timæus, that in the earlier ages a communication existed between the Phlegræan Fields and Ischia: and it has been observed that when Vesuvius is quiescent, the Solfatara is active, showing its activity by emitting unusual clouds of smoke and vapour, accompanied by internal noises. However, the only eruption from the Solfatara which has been put on record is that of 1198, when it poured forth a stream of lava that to this day may be traced from its opening in the south-east wall of the crater to the sea. This lava decomposes into a kind of ochreous earth, whose yellow colour is due to the presence of oxide of iron; but it becomes red after it has been calcined, and is then used as a pigment.

The present condition of the Solfatara is almost identical with that described some sixteen centuries ago by Cornelius Severus:—

“ Neapolim inter,
Et Cumas, locus est multis jam frigidus annis,
Quamvis æternum pinguescat ab ubere sulphur.”

A graphic sketch is furnished by Petronius Arbiter:—

“ Est locus in exciso penitus demersus hiatu
Parthenopen inter magnæque Dicharchidos arva
Cocyta perfusus aqua. Nam spiritus extra
Qui furit, effusus funesto spargitur æstu.
Non hæc autumnus tellus viret, aut alit herbas
Cespitæ lætus ager: non verno persona cantu
Mollia discordi strepitu virgulta loquuntur:
Sed chaos, et nigro squallentia pumice saxa
Gaudent ferali circum tumulata cupresso.”

The rock of which the Solfatara is composed is, says Daubeny, naturally hard and dark-coloured, but in proportion as it is exposed to the action of the sulphuretted hydrogen and other gaseous vapours, its texture and

colour undergo a remarkable alteration. The first stage of the process seems to be a mere whitening of the mass, in consequence of the removal of the iron to which its colour is attributable ; next it becomes porous and fissile ; when the process is further advanced, we see the rock honeycombed like a bone that has undergone the action of the weather ; until at length it crumbles into a white powder, consisting almost entirely of silex.

The saline substances which effloresce on the surface of the rock consist of muriatic salts ; of the sulphates of iron, lime, soda, magnesia ; and, above all, of alumina. They appear in almost the same proportion as that in which they would result from the action of the same gas upon a stone similarly constituted.

Meanwhile, the sulphur deposited diffuses itself through the rock, and lines the walls of its cavities ; but, according to Breislac, this is due entirely to the sulphuretted hydrogen, and is not sublimed in an uncombined state ; since it occurs only in those parts of the mountain which, from their proximity to the surface, admit of the ready access of atmospheric air. Occasionally it is accompanied with sulphuret of arsenic ; which, says Daubeny, has probably also been disengaged, combined with hydrogen, and is, perhaps, the cause of the destructive exhalations which frequently succeed an eruption.

The deleterious influence of its gases is not limited to the immediate area of the Solfatara, but extends to a considerable distance on the hills which bound it to the north, where the rocks are all whitened and decomposed owing to their action, prolonged, as we know it to have been, through many ages.

It was in allusion to this circumstance that the ancients designated them the *Colles Leucogæi* ; for Pliny mentions certain medicinal waters, called *Leucogæi Fontes*, as existing between Pozzuoli and Naples, and a thermal spring still rises at Pisciarelli, situated on the slope of the vine-clad hills.

Ischia (the ancient *Inarime*) is one of the fairest of the islands which stud the Gulf of Naples. Its picturesqueness would furnish an artist with material for the study of a lifetime, and nourish in the brain of a poet the most enchanting dreams. Bishop Berkeley justly describes it as "an epitome of the whole earth." Within the narrow compass of a score of miles you may find the most delightful variety of shadowy vales, deep wooded glens, swelling hills, rugged rocks, plains radiant in bloom and verdure, and lofty mountain-peaks, all accumulated in a strange but felicitous confusion. Even in the sunniest days of summer the warm air is agreeably tempered by cool breezes from the sea. The vales yield prodigal crops of wheat and maize, while their slopes are covered with vineyards and orchards. Nearly to their summit the hills bloom with vines, and chestnut groves, and thickets of myrtle and lentiscus. And on the brink of wave-worn cliffs stands an ancient castle, which lends to the landscape a singular impressiveness of character.

But the most striking feature of the scene is Monte di San Nicola, the Epomeus of the Greeks. "Its lower parts are adorned with vines and other fruits ; the middle affords pasture to flocks of goats and sheep ; and the top is a sandy pointed rock, from which you have the



CASTLE OF ISCHIA

• finest prospect in the world—surveying at one view, besides several pleasant islands lying at your feet, a tract of Italy about three hundred miles in length, from the promontory of Antium to the Cape of Palinurus.”

Ischia is separated from the island of Procida by a strait about two miles broad. Its circumference, if you exclude the numerous indentations of its coast, measures upwards of twenty miles. Its length is seven miles ; its minimum breadth, four miles. Prior to the renewal of the outbreaks of Vesuvius in the first Christian century, this island was the principal scene of volcanic action in Southern Italy. It is composed of pumiceous tufa, which in many places assumes a trachytic character, and is not unfrequently diversified by beds of pumice and obsidian. Its *Monte di San Nicola*, to which we have referred, raises its huge bulk nearly in the centre of the island. It is conjectured that it acted chiefly by lateral eruptions, for no lava is visible near its crest, though as many as twelve cones are conspicuous on its flanks and on various parts of the plain which forms its base. To the north and west the descent of the island to the sea is gradual ; on the south and east it is more abrupt, and the coast is elevated into lofty precipices, worn by the incessant action of the rolling waters of the Mediterranean.

It has been elegantly remarked that the volcanic action of Ischia is intimately associated with its early history ; and that the connection of its volcanic phenomena with the ancient mythology has invested it with a peculiar attraction.

Its earliest settlers, a Greek colony from Chalcis and Eretria, seem to have suffered greatly from constant earthquakes and other manifestations of volcanic agency, and, finally, to have been compelled to abandon the island. It is supposed that these convulsions

were identical with those recorded by Timæus, who flourished about 262 B.C., and who narrates a tradition that shortly previous to his time Mons Epomeus had poured forth fire and ashes, while the belt of land between it and the sea was broken up and overwhelmed in the waters, which, after a sudden reversion, suddenly returned, swept the shore for miles, and extinguished the fiery lava. These incidents are also mentioned by Pliny. A colony founded by Hieron, King of Syracuse, about 470 B.C., was also driven from the island by its volcanic outbursts. An eruption took place in B.C. 92; also, in the reign of Titus, Antoninus, and Diocletian. Since 1302 the subterranean fires have remained tranquil.

The ancient poets, in their wayward play of fancy, were pleased to attribute the volcanic phenomena of which *Ischia* (or *Inarime*, as it was called) was the theatre, to the struggles of the Titan Typhœus, whom the Gods had vanquished, fettered, and imprisoned :—

“ There on his flinty bed outstretched he lies,
Whose pointed rock his tossing carcass wounds :
There with dismay he strikes beholding eyes,
Or frights the distant ear with horrid sounds.”

So says Pindar, while Homer also alludes to the captive giant :—

“ On Arime where Jove his thunder throws,
And fires Typhœus with redoubled blows,
Where Typhon, pressed beneath the burning load,
Still feels the fury of the avenging God.”

By these romantic associations, however, we must not suffer ourselves to be detained; nor can we permit ourselves more than a passing reference to the memories of the beautiful and virtuous Vittoria Colonna, which hallow Ischia with an immortal glory. We must look “beneath the surface,” in accordance with the object of the present volume, and there we find abundant evidence of incessant volcanic action. No spot of the same extent, it has been said, contains such a number of hot mineral waters. “The island is so rich in springs, that

many valuable waters, which would make the fortune of any town in continental Europe, are here allowed to run to waste. The principal characteristics of the Ischia waters are the large quantities of the hydrochlorates, sulphates, and carbonates of soda which they contain; combined with the salts of magnesia, of lime, and occasionally of potash, and with a considerable volume of carbonic acid gas. With a few exceptions, they issue from the earth at so high a temperature that it is necessary to mix them with cold water before they can be used. Besides the waters, there are sand-baths of great power, and hot-air and vapour baths varying in temperature from 140° to 180° ."

The most important of these springs are situated in the Valle Ombrasco, a leafy glen at the base of Monte Epomeo, near the picturesque village of Casamicciola. They are as follows:—

The *Gurgitello*, whose temperature is 158° , and whose waters are charged with large proportions of carbonate and muriate of soda, and 9 cubic inches per cent. of free carbonic acid gas.

The *Acqua di Cuppona*, whose temperature is 98° F., and whose name is derived from the smell of "chicken broth" which its waters undoubtedly possess.

The *Acqua del Occhio*, an alkaline water, useful in diseases of the eyes.

The *Acqua di Tamburo*, which contains such quantities of carbonic acid gas that its escape is accompanied by a sound like the roll of a drum. Temperature, 155° to 210° F.

The *Acqua Aurifera-Argentea*, so named of old from a belief that it contained gold and silver.

The *Acqua di Rivaz*, with a pungent bituminous smell, has a temperature of 176° .

The *Acqua Spenna-pollustro*, with a temperature varying from 167° to 180° .

The *Acqua Colata*, a strongly alkaline water, with a temperature of 178° .

The *Acqua Cociva*, with a temperature varying from 178° to 190° .

The *Acqua della Sciatica*, with a temperature of 144° ; and

The *Acqua delle Rete*, whose temperature at its source varies from 149° to 158° .

In the higher part of the glen we find the *Fumaroli di Frussia* and *di Monticelo*; the former emitting vapour at the temperature of 126° , and the latter at that of 203° .

Numerous thermal springs, of a high temperature, occur in the neighbourhood of Lacco, Forio, Pauza, Morossano, and Ischia, giving a very striking and even startling idea of the tremendous igneous activity which must prevail beneath the surface. How formidable must be the furnace, to keep ever seething and flowing these heated waters, which, day after day, and night after night, throw off their burning vapours! On the shore near Morossano are situated some *fumeroles* of such remarkable potency that they raise the surrounding sand to the temperature of 212° . From the *Stufa di Testaccio* issues a blast, so to speak, of hot air, which withers the traveller's cheek like the breath of a lime-kiln. The temperature of the *Stufa di Caccinto* is 160° . The *Acqua di Castiglione* raises the thermometer plunged into its stream to 167° ; and the sand on the neighbouring shore

is so hot that it raises the thermometer to 212° . In truth, the romantic island of Ischia, with its hills and ravines and plains, would seem to be but a crust or layer, extended over a tremendous internal furnace, whose gases and vapours are continually forcing their way into the upper air.

The Geysers of Iceland may next claim our attention. Though the effects of the phenomenon are external, its causes are to be sought beneath the surface.

The following admirable description is borrowed from Lord Dufferin's "Letters from High Latitudes" :—

We found ourselves, he says, in the presence of the steaming Geysers.

I do not know that I can give the reader a better notion of the place than by saying that it looked as if—for about a quarter of a mile—the ground had been honeycombed by disease into numerous sores and orifices. Not a blade of grass grew on its hot, inflamed surface, which consisted of unwholesome-looking, red, livid clay, or crumpled shreds and shards of slough-like incrustations. Naturally enough, our first impulse on dismounting was to scamper off at once to the Great Geyser. As it lay at the furthest end of the congeries of hot springs, in order to reach it we had to run the gauntlet of all the pools of boiling water and scalding quagmires of soft clay that intervened, and consequently arrived on the spot with our ankles nicely poulticed. But the occasion justified our eagerness. A smooth silicious basin, seventy-two feet in diameter and four feet deep, with a hole in the bottom as in a washing-basin on board a steamer, stood before us brimful of water just upon the simmer; while up into the air above our heads rose a great column of vapour, looking as if it were going to turn into the Fisherman's Genie (in the "Arabian Nights" stories). The ground about the brim was composed of layers of incrustated silica, like the outside of an oyster, sloping gently down on all sides from the edge of the basin.

We kept watch for three days over the geyser, in expectation of

the eruption. On the morning of the fourth day, a cry from the guides made us start to our feet, and, with one common impulse, rush towards the basin. The usual subterranean thunders had already commenced. A violent agitation was disturbing the centre of the pool. Suddenly a dome of water lifted itself up to the height of eight or ten feet, then burst, and fell; immediately after which a shining liquid column, or rather a sheaf of columns, wreathed in robes of vapour, sprung into the air, and in a succession of jerking leaps, each higher than the last, flung their silver crests against the sky. For a few minutes the fountain held its own, then, all at once, appeared to lose its ascending energy. The unstable waters faltered—drooped—fell, “like a broken purpose,” back upon themselves, and were immediately sucked down into the recesses of their pipe.

The spectacle was certainly magnificent; but no description can give any idea of its most striking features. The enormous wealth of water, its vitality, its hidden power; the illimitable breadth of sunlit vapour, rolling out in exhaustless profusion,—all combined to make one feel the stupendous energy of Nature’s slightest movements.



THE GREAT GEYSER.

And yet, says Lord Dufferin, in conclusion, I do not believe the exhibition was so fine as some that have been seen. From the first burst upwards to the moment the last jet retreated into the pipe was no more than a space of seven or eight minutes, and at no moment did the crown of the column reach higher than sixty or seventy feet above the surface of the basin. Now, early travellers talk of three hundred feet—which must, of course, be fabulous; but many trustworthy persons have judged the eruptions at two hundred feet; while well-authenticated accounts—when the elevation of the jet has been actually measured—make it to have attained a height of upwards of a hundred feet.

It has been pointed out that a simple experiment will account for the intermittent action of these remarkable fountains. Let the reader pour a stream of water through a bent tube depressed about the centre, and heated in that part alone. Under these circumstances, the steam suddenly generated at bottom, will force one portion of the water out in a jet from the opposite extremity to that at which it entered, driving back, at the same time, the current of water continually entering. Under such conditions the water will be expelled in sudden intermittent jets; and there can be no doubt that in this way we may explain the recurrent phenomena of the Geysers.

If we could remove the outer shell of the earth, as we do the rind of an orange, what a spectacle of incessant activity would be presented to the astonished gaze! Streams of lava, currents of boiling water, volumes of vapour and noxious gases, rivers of molten rock and mineral; all struggling to find their way to the surface; all set in motion and kept in motion by the wonderful potency of the great central fire.

It would be foreign to the plan of this volume to dwell at any length upon volcanic phenomena. Yet it seems desirable to give the reader an idea of the effect of igneous action, and of its marvellous character, even when it does not manifest itself in the form of an earthquake or a violent eruption.

For this purpose, we cannot do better than abandon the bleak, inhospitable regions of the Arctic Pole, and betake ourselves to the southern hemisphere, and the islands of New Zealand.

New Zealand, the reader will remember, consists of two large and one small islands, named respectively North, Middle, and South. All three are of volcanic origin, and a great portion of their area is occupied by a few active and several extinct volcanoes. In North Island the volcano of Tongariro is 6000 feet in height, and constantly discharges enormous columns of vapour and smoke. In Middle Island, around Lakes Rotorna and Rotomahana, numerous magnificent geysers have been discovered, which eject columns of boiling water. But of higher interest is the remarkable district of the Lake Taupo, in North Island; a district thirty miles in length, by twenty miles in breadth, which has been carefully explored by the traveller Hochstetten.

Lake Taupo he describes as an inland sea, measuring twenty-five miles in length, by twenty in breadth, while its depth seems to be unfathomable. It is situated 1250 feet above the level of high-water mark, occupying the site of an ancient crater, and surrounded everywhere by vol-

canic formations, in which gigantic masses of pumice-stone and trachytic quartzose lavas predominate. These igneous rocks are accumulated so as to form a great table-land, from 2000 to 2200 feet in height, in whose centre lies the soundless, silent lake.

The entire western shore is bounded by giant precipices, which, at some points, attain an elevation of 1000 feet and upwards. The long, wooded crests of Mounts Rangitolo and Truhua, 3000 feet in height, extend against the north-western horizon; and as a black speck on the remote sky, the traveller first makes out the pyramidal mass of Mount Titirapeuga, whose broken summit resembles the ruins of a dismantled castle.

The eastern margin is generally level, and forms a continuous beach, along which a road has been laid down. At intervals it is bounded by glittering pumiceous crags, which bloom with luxuriant vegetation, and gradually rise towards the foot of a lofty pine-clad mountain, Kaimanawa, situated about fifteen miles from the lake.

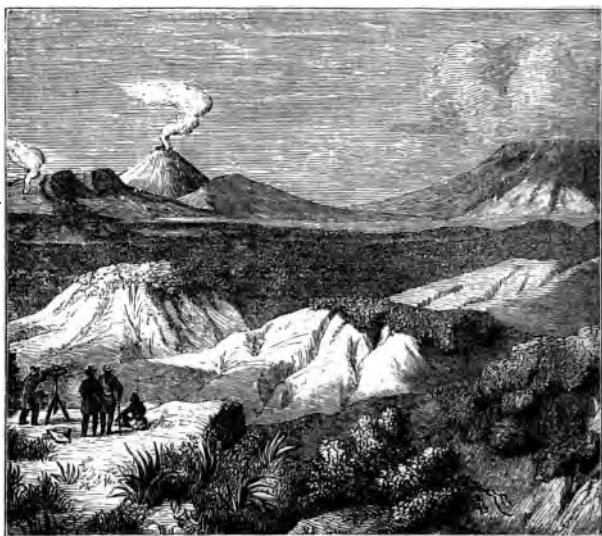
The southern shore of Lake Taupo stretches far away. It is bordered by a range of volcanic cones, in whose rear tower the magnificent masses of Tongariro and Ruapahou. From the immediate margin of the lake, however, these volcanoes are invisible; but from the east to the north they may be seen grandly soaring above those little conical peaks which the natives, in their picturesque language, designate their "wives" and "children."

The base of Mount Tongariro lies about twelve miles inland. Between its bulk and the mountains Pihanga and Kakaramea reposes a broad and beautiful valley,



forming the basin of Lake Rotoaia, and about three miles in length.

Tongariro, however, is not an isolated cone, like Ruapahou, but, on the contrary, a complex system of powerful and still active volcanoes, of which Ngaurahoe, a superb and regular cone of eruption, with an immense



MOUNTAINS OF TONGARIRO AND RUAPAHOU.

funnel-shaped crater, is the highest and most conspicuous peak.

Ruapahou lies south of Tongariro, the bases of the two mountains blending into one another by an imperceptible incline, and forming a kind of table-land about ten miles broad. On this table-land lie four lakes, two of

which measure about three miles across, while the others are considerably smaller. One of them is named Taranaki ; the river to which it gives birth empties itself into the Whanganni, and to this lake a curious tradition is attached.

The natives say that Taranaki (the *Mount Egmont* of our English maps) formerly stood, like a third giant, by the side of Tongariro and Ruapahou. They lived long on the friendliest terms, as giants surely ought to do, until Taranaki made an attempt to carry off Pihinga, the wife of Tongariro. No wonder that the latter immediately quarrelled with his ill-conditioned associate, and dealt him a blow on the head which made him take to flight. He descended the course of the Whanganni, and following the line of the deep river-valley, approached the sea, where, at a point near the coast, he now rears his colossal and solitary bulk. During his journey a couple of fragments detached themselves from his forehead ; and to-day, in confirmation of their extraordinary narrative, the natives point to two masses of rock, wholly different from the volcanic formations of the basin of the Whanganni, which lie about eighteen miles distant from its source.

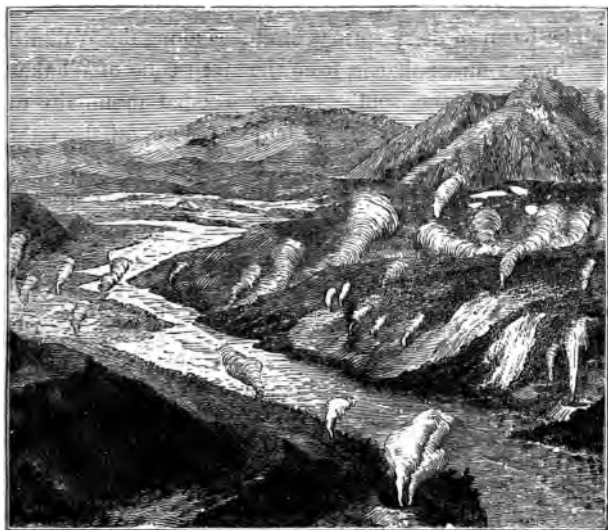
Ruapahou, the loftiest summit of the Northern Island, assumes the form of a considerably truncated cone, and rises far above the boundary-line of the region of perpetual snow. It has never, we believe, been ascended or explored ; no doubt, however, exists as to its volcanic nature, but the igneous action appears to be completely silenced, and, at a distance, no trace even of a solfatara

is visible either on its sides or summit. Whether the summit is excavated in a crater, or forms a table-land, is not known. It is seldom free from clouds ; but in clear weather huge wreaths of snow are seen to adorn its sides, and, plunging deep into their furrows, terminate apparently in glaciers.

Most of the hot springs of this region are situated on the southern shore of Lake Taupō—of whose immediate neighbourhood the reader, it is presumed, will now have formed an accurate conception—not far from the Maori settlement of Tokanu, and close to the river of that name. They extend from the little conical mountain Manganamu to the mouth of the river, occupying an area of about two English square miles. The dense column of vapour discernible on the margin of the lake rises from the great spring of Pirori. From an opening on the left bank of the Tokanu mounts a shaft of **boiling** water two feet in diameter, which whirls round in the **air** at a height of from six to ten feet. Occasionally, **indeed**, it attains an elevation of forty feet, and a loud **report** accompanies its propulsion. A few feet distant lies a basin eight feet broad by six feet deep, in which the water is constantly boiling.

Similar thermal springs abound in the Waikato valley. The Waikato, forming in its course a succession of vapours, dashes headlong through a narrow ravine which it has excavated for itself through the very heart of a mass of precipitous mountains. Its waters seethe and eddy around two rocky islets situated in the centre of its

bed, and then, with a roar like that of continuous thunder, swirl far into the bosom of the valley. White clouds of vapour, engendered by the numerous springs which flow towards the river, constantly hover above its banks. Here a column of vapour rises, to sink again in showers of water-drops ; there another springs aloft, to



THE WAIKATO VALLEY.

pause suddenly, as if checked by some insurmountable obstacle ; a third begins to play, and then a fourth ; and so the game is diversified and renewed, as if Nature designed to show what aqueous action was capable of accomplishing. There is no lack of water ! When all the fountains simultaneously open, the cascades show no signs of diminution. Hochstetten set himself the task of

counting the different places where a basin of boiling water was visible, or the fleecy vapour-cloud marking the site of one. He numbered sixty-six, without, however, being able to include the whole in his survey; and, moreover, many of the springs enjoy long intervals of rest, like the Icelandic geysers.

The basin of these springs stretches along the Waikato for about a mile; that is, from the steep cone of Whakapaparinga, on the south, to the wooded mountain of Tutukau on the north. The majority lie upon the right bank, but they are not easily accessible; and it is better, therefore, for the traveller to rest contented with an examination of those on the left bank, which exhibit the same phenomena.

A great platform, about one hundred and twenty yards square, composed of a white silicious tufa, and extending from the base of Tutukau to the bank of the Waikato, contains some of the most interesting springs of the basin, and among them that of Homaiterangi.

This spring is situated near the river-bank, and rises from a curiously-shaped hillock, resembling a church spire. The traveller who, without an experienced guide, for the first time approaches one of these *pinas*, needs to be very cautious. Some of Hochstetten's companions were desirous of a bathe and a swim in the Waikato, and had taken off their clothes for this purpose, when they were startled by a succession of loud reports, and a hot jet of water began to play in their immediate neighbourhood. They had barely time to escape a douche-bath

of the most disagreeable character; for the liquid column, mixed with steam, sprang up, hissing and roaring, to a height of twenty feet. Startled by this adventure, they hastened to relate it to Hochstetten; but when he arrived on the spot, the geyser had sunk into a state of sullen repose, and nothing was visible in its basin but water clear as crystal, and very slightly disturbed. Its temperature proved to be as high as 201° R. (194° C.), and its taste was not unlike that of broth.

The first explosion of which Hochstetten was an eyewitness did not take place until near noon. The basin was full to the brim; suddenly masses of water and vapour shot up to an elevation of from twenty to thirty feet, under a circle of about 70° . This operation continued for several minutes; then the propulsive force diminished, the water rose only one or two feet, and finally the jet disappeared in the centre with a hoarse dull noise. When Hochstetten again approached the basin he found it empty, and he could see to a depth of eight feet in a funnel-shaped opening, whence gusts of vapour escaped with a constant hiss. Then the water resumed its upward movement, and in the course of ten minutes the basin was filled anew. The eruptions appeared to take place at intervals of ten hours.

The bed of this *pina*, like that of the neighbouring springs, consists of silicious tufa. The sediment deposited by the waters is of a gelatinous white, while fresh; after awhile it acquires consistency; and finally it hardens into a solid rock of very different colour and structure. Sometimes it is a granulated mass, sometimes a chalcedony hard as steel, and sometimes a gray silica.

A second *pina*, about thirty paces distant from the first, is named Orakeikorako. It is an oval basin, eight feet long by six feet broad, and partially filled with a translucent and ebullient water.

The most remarkable of all the springs, however, is situated at the foot of the hill; a boiling jet, two or three feet in height, whose water is exquisitely bright and clear, though throwing off an odour of sulphur. The Maori chief who attended Hochstetten in his excursion informed him that, after the earthquake at Wellington in 1848, this spring was transformed into a geyser, which rose to an elevation of one hundred feet, and ejected with terrible force the stones thrown into its basin. Three smaller basins, which at one time must have been independent sources, are now filled by the overflow of the great jet, and form excellent natural *piscinæ*. The water passes from one reservoir into another, so as to afford a choice of three temperatures. The third, about three to five feet in depth, is nearly as large as an ordinary bath. Its bed is composed of silicious tufa, white as snow, which possesses apparently the purity of marble, and the limpidity of the wave rivals that of Horace's famous "*fons Bandusiæ*."

Great curative virtues are attributed to these springs. Hochstetten met with an Irishman at Orakeikorako who informed him that a brief course of bathing in them had cured him of a severe paralytic affection.

On both sides of the river the thick brushwood covers tracts of boiling mud, which require to be approached with the utmost caution; for the soft soil, not being

strengthened by any admixture of tufa, yields beneath the slightest pressure. The largest of these mud-basins assumes the form of an ellipsis, whose major diameter measures fourteen feet, and its minor eight feet, and whose depth is eight to nine feet. Within this caldron boils a bright red mud, deriving its colour from oxide of iron; while viscous bubbles of slime, rising incessantly to the surface, burst and emit a fetid sulphureous stench: the scene is described as "truly infernal." Woe to him whose foot slips in a neighbourhood so perilous! The misadventure means certain death, and a death of terrible agony.

On the opposite bank is situated the *pina* of Tuhi-Tarata. The sapphire water, issuing from its basin, descends, like a rushing flood of vapour, a succession of tufa terraces, radiant with the most various colours,—with red, and yellow, and white. A similar scene is presented at several points, accompanied by transient jets at longer or shorter intervals.

Hochstetten's next expedition was to Rorotua, a volcanic lake fed by these thermal springs, and commended to the veneration of the Maories by its association with a very ancient legend. Most of the Maori families of the North Island with any claim to the possession of "blue blood" trace back their lineage to Hine-Moa, the virgin of Rorotua.

In the neighbourhood of the lake lies the small basin of the Rotomahana, which measures about 1500 yards in length by 600 in breadth. It is a real crater of eruption; deep in the centre, bounded by morasses on the north



ROTOMAHANA LAKE.

and south, and hemmed in by rocks on the east and west. It may appropriately be termed a *thermal* lake : the quantity of boiling water flowing from the contiguous springs is so considerable as to heat the entire contents of the basin.

To the north is situated the Té-ta-Rata, a boiling spring which, descending terrace after terrace in its course to the lake, is the greatest wonder of a region of wonders.

On a ferny hill-side, about eighty feet above the Rotomahana, is found the principal basin, whose banks of reddish clay are from thirty to forty feet in height. It measures about eighty feet long by sixty feet broad, and

is filled to the brim with a perfectly transparent water, which, owing to the snowy whiteness of the stalactites on its margin, shines with a rich turquoise blue, occasionally iridescent with luminous opaline tints.

The thermometer at the edge of the basin marks 183° F.; in the centre, where the water forms a jet of several feet in height, it rises to boiling-point (212° F.).

Immense masses of vapour reflecting the glorious deep blue of the basin, swirl and hover above it, and obstruct the curious gaze; but the hoarse sound of its ebullient waters is never hushed. Sometimes, if the natives may be credited, the entire mass of seething fluid is ejected with an almost inconceivable violence; and then, to a depth of thirty or forty feet, may be seen the empty basin—which, however, very speedily refills.

If this be really the fact, the spring of the Té-ta-Rata is neither more nor less than an intermittent geyser, like the Great Geyser of Iceland; but, as the basin is larger, the quantity of water discharged is necessarily more considerable.

The flavour of the water is brackish, but not so strong or disagreeable as in the Icelandic springs. The deposit is a silicious stalactite. In overflowing the basin, the water has formed a series of ledges, or stages, which, white and pure as Parian marble, present a very beautiful and charming appearance.

The prolonged spur of the hill stretches far forward into the Rotomahana: above commences a range of terraces, containing several basins, whose depth corresponds to the height of the several steps of this gigantic staircase. Each step is bordered by a slightly elevated

rim, over which a myriad elegant stalactites droop upon the ledge beneath ; and each presents a platform of greater or lesser extent, inclosing one or more basins of an exquisite azure. These basins form so many natural baths, which all the resources of modern art could not render more convenient or attractively graceful. So great is their number, and so various their temperature, that you may select one of whatever size or degree of warmth you prefer. Some are large enough to serve as swimming-baths.

The loftiest terrace surrounds a large platform or area, in which occur numerous graceful basins, from five to six feet in depth, whose water has a temperature of 86°, 90°, 104°, and 122° F. In the centre of this area, and near the principal basin, a rock about twelve feet high is thickly clothed with manuka, lycopodiums, and mosses and ferns generally ; the traveller can easily climb it, and from its summit look down into the blue vaporous depths of the middle basin. Such is the celebrated spring of the Té-ta-Rata. The pure white of the stalactites contrasting with the intense blue of the water, the rich bloom of the encircling vegetation, the bright red of the crater-walls, and, finally, the incessantly whirling and rotatory clouds of mist and steam, combine to form a picture of the most singular and most impressive character.

The splendours of the Té-ta-Rata, says M. de Lanoye, have a rival on the opposite bank of the lake in those of a spring not less remarkable for its high temperature and stalactite deposits. It has received from the natives the expressive name of Otaka-Puarangi, or the "Cloudy Atmosphere." Its white silicious incrustations, like those

of the Té-ta-Rata, descend from its basin down to the lake beneath, and the traveller climbs to the summit by a marble staircase, as it were, so sharp in its outline, so regular in its construction, and so richly embellished with graceful borders of evergreen shrubs, that it seems as if Nature had designed it to show how easily she can outvie the skill and industry of man.

It may be that the overhanging terraces of the Otaka-Puarangi are not so nobly imposing as those of the Té-ta-Rata; but they are more elegant, more graceful, and the delicate rosy hue which overspreads the entire calcareous deposit invests the scene with a peculiar beauty. The basin of the spring, forty to fifty feet in breadth, encloses a tranquil sheet of water of a fine lustrous azure; a water which does not boil, but throws off a constant evaporation.

At the northern base of the terraces smokes a solfatara, the Whakur-Taratana, which may be described as a complete pond of sulphur, whose overflow empties itself into the lake with a tawny, turbid current.

From these details the reader will be able to understand that the Lake Taupo district, "beneath the surface," must be a surprising and almost terrible spectacle of igneous activity.

We are naturally led by the reflections which the foregoing description cannot but suggest to every thoughtful mind, to inquire into the probable temperature of the globe. It is a well-known fact that that temperature increases in proportion as we descend into the "bowels

of the earth." But by what ratio? What is the law which regulates this increase?

As the mean result of a great number of experiments, it has been calculated that the increase is one degree for every 110 feet. But from this normal standard the variations are almost innumerable, according to the greater or less facility with which the rocks *in situ* conduct caloric. Some retain heat with greater tenacity than others.

The first measurements of the internal heat of the globe seem to have been made by Gensaune, about 1740, in the lead-mines of Giromagny (in the Vosges). As the result of his experiments he estimated an increase of 1° for 61 feet.

Towards the close of the eighteenth century, De Saussure, the Alpine explorer, remarked that the Alpine glaciers melt away at their base with the return of the hot season. This fusion he ascribed to the natural heat of the earth, and thus he was led to undertake, in several localities, experiments in reference to the modifications of temperature in the earth's interior. His observations in the salt-mines of Bex induced him to fix the regular increase at 1° for every 125 feet of depth.

In one of the ablest contributions which has ever enriched the literature of physical science, Cordier, revising the conclusions of previous inquirers, and carefully avoiding the errors into which circumstances had led them, laid down several important and unassailable principles. He demonstrated the existence of local variations of the terrestrial temperature, but he also demonstrated the fact of the regular augmentation of that temperature.

He found an increase of 1° for 120 feet in the mines of Carmeaux (department of the Tarn), 1° for 64 feet in those of Hittry (department of Calvados), and of $\frac{1}{3}^{\circ}$ for 50 feet only at Decize (department of Nièvre). He concluded therefore that the mean rate of increase may be estimated at 1° for 80 feet,—or, more strictly, for 78 feet ($120 + 64 + 50 = 234 \div 3 = 78$).

In the mines of Cornwall a new mode of measuring the temperature was introduced a few years ago; namely, by ascertaining the temperature of the waters pumped out of the shafts. Seventy thousand tons of water were daily brought to the surface, and the exact depth of the mine was calculated; the temperature of the water therefore accurately represented that of the reservoir whence it issued. These experiments indicated the same result as that already obtained by De Saussure; namely, 1° for every 125 feet.

In the Dolcoath copper-mine, however, a thermometer buried three feet in the rock, at a depth below the surface of 1377 feet, showed a temperature of 75.5° F., while that of the upper air was only 50° , showing a rate of increment of 1° for every 54 feet.

In the coal-pits at Killingworth, the scene of the early labours of George Stephenson, the annual mean temperature at the surface is 48° F.; at a depth of about 900 feet, 70° ; and at 1200 feet, 77° .

In the Erzgebirge mines of Saxony an extensive series of observations was carried on for a period of ten years, with the view of determining the temperature of the rocks by thermometers sealed up in the solid stone. These

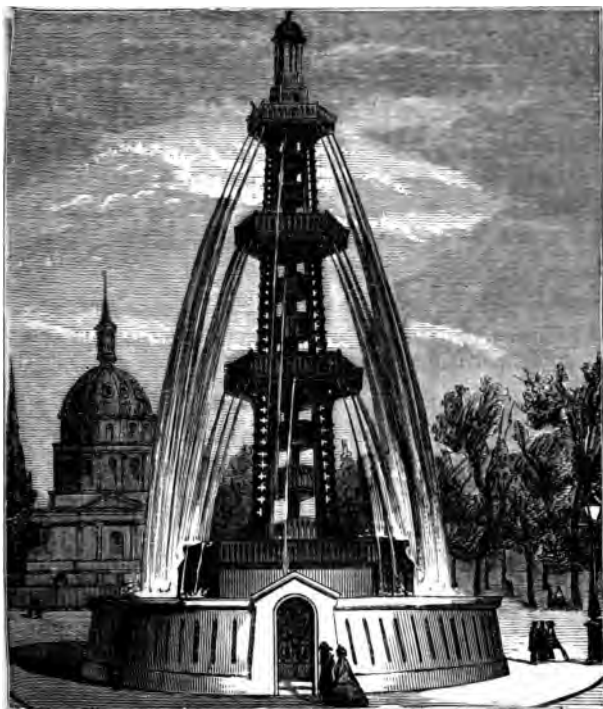
were all arranged on the same vertical line. The experiments were conducted in twenty different mines, extending over an area of about 25 square miles. The instruments were examined several times monthly, and the mean of these observations taken for each month, and afterwards for each year. The result was, out of upwards of four hundred observations, taken at levels varying between 65 feet and 1100 feet, that the rate of increase was represented by 1° for 140 feet.

Similar experiments made in the mines of the Ural led M. Kupffer, however, to conclude that the rate was as high as 1° for 65 feet; while in some of the Scotch mines it has been found not to exceed 1° for 205 feet. We may remark that the temperature seems in every case to increase more rapidly in coal-mines than in metal-mines.

The remarkable discrepancies of these results show that the most careful observations of the temperature prevailing in the interior of mines afford no trustworthy basis for scientific calculations.

We find a more accurate method by having recourse to the Artesian wells, now so common in every part of Europe. The depth of a boring on the Artesian principle can always be exactly ascertained; and the temperature of the water which it carries to the surface of the earth must indicate, with scarcely a possibility of error, the temperature of the point whence it has arisen, inasmuch as the water has not time to cool to any important extent.

The Artesian well of Grenelle is 1798 feet deep, and the temperature of its water $81^{\circ} 7' F$. Now, the mean



THE ARTESIAN WELL OF GRENELLE.

temperature of the climate of Paris is 53° F. Hence, this water extracts from the bowels of the earth no fewer than $28^{\circ} 7'$ F. of heat, or about 1° for every 65 feet.

A similar datum is furnished by the Artesian well of Passy, which is 1860 feet in depth, with a temperature of $82^{\circ} 25'$ F.

Walferdin introduced into the "bore" of several

Artesian wells some skilfully constructed *thermomètres à diversement*,* so disposed as to resist the pressure of the water, and to indicate, with almost unimpeachable accuracy, its true temperature. In the wells of the Ecole Militaire at Paris, Saint-Andrè (department of the Eure), and Grenelle, an increase of 1° for every 100 feet was ascertained. The experiment was made in the first well at a depth of 565 feet, in the second at 825 feet, and in the third at 1300 and 1650 feet.

More recently, at Creuzot, Walfordin obtained a rise of 1° for every 55 feet down to 1800 feet, and of 1° for every 44 feet below that level.

We may add that an Artesian well, 725 feet in depth, having been opened up at Pregny, M. de la Rive, of Geneva, succeeded in introducing thermometers at various depths, with the result of ascertaining a rate of increase equal to 1° for every 165 feet.

A comparison of these various results leads us to the mean, now generally accepted by physicists, of 1° for every 110 feet.

The depth to which observations of this kind can be carried, however, is not very great; for no Artesian wells have been sunk lower than 2280 feet, and our deepest mines do not exceed 6600 feet. Experiments in reference to the internal heat of the earth, if pushed to the furthest limits of human adventure, cannot therefore arrive at a higher temperature than 176° . And *this* temperature has never been observed with any instruments hitherto in use. We are enabled, not the less, by

* Thermometers made after a variety of patterns.

means of a remarkable physical phenomenon, to establish as a fact beyond doubt the existence of far higher temperatures "beneath the surface."

Certain mineral springs, for example, which rise to the surface of the soil, possess, as we have already shown, a temperature varying from 160° to 212° F.*

We have also referred to the Geysers of Iceland, the temperature of which at the point of emergence exceeds 212° , and at a few yards below the surface, 256° F. This intense heat would seem to be due to the great depth at which their reservoir is situated.

But another, and a still more important geological phenomenon, proves, beyond the possibility of confutation, the existence, in the interior of the globe, of a temperature which cannot be less than 2732° F. Numerous observations, made during the eruptions of Vesuvius, have shown that the lavas ejected from its crater, and distributed over its declivities, possess an almost incredible intensity of heat. Cast into the slowly flowing lava some pieces of glass, or even of harder substances, such as basalt or granite, and you will find that they fuse immediately on coming into contact with it. Frequently,

* We subjoin a list of some of the best-known thermal springs, with their ascertained temperature. The most celebrated will be described in the following pages:—

Matlock, Derbyshire.....	68° F.	Aix-les-Bains, France.....	117° F.
Buxton, Derbyshire.....	82°	Montiers, France.....	101°
Stoney Middleton, Derbyshire.	70°	Vichy, France.....	104°
Cross Bath, Bath.....	109°	Baréges, France.....	120°
King's do., Bath.....	114°	Carlsbad, Germany.....	165°
Hot do., Bath.....	167°	Moffat, Scotland.	
Insprung, Baden.....	153° $30'$	Bridge of Allan, Scotland.	
Saint-Gervaise, France.....	98°	Pitcaithly, Scotland.	

in the interesting excavations which have been conducted at Pompeii, bars and fragments of iron, curtain-rings, and the like, as well as gold and silver coins, have been discovered in a semi-molten condition, having been liquefied by the action of the volcanic ashes. As the fusing-point of iron is about 2032° F., this single fact demonstrates that the temperature of the interior of our globe cannot be less. We repeat these details in reply to an objection sometimes put forward, that no direct experiments made in the terrestrial strata have shown a higher temperature than 86° to 104° F.

We consider, then, that it has been satisfactorily proved that the temperature of the globe increases in proportion to the measure of its diameter, and that that increase may be calculated at the mean rate of 1° to every 110 feet.

If we admit that this rate of increment continues to the earth's centre—an hypothesis which can neither be supported nor rejected on any mathematical data—it would result that the temperature of the terrestrial nucleus cannot be less than $383,000^{\circ}$ F., representing a maximum of heat of which the human mind is wholly unable to form an accurate conception. At a depth equal to one-fiftieth of the earth's diameter, the heat would equal $14,254^{\circ}$ F. (or 100° of Wedgwood's pyrometer), a heat capable of melting all the lavas and most of the known rocks; finally, at a depth of 8100 feet, a temperature of 212° F.—or, in other words, boiling-water heat—would prevail.

Hence a French writer has been pleased to conclude that if the art of boring Artesian wells should one day be so developed as to carry the tubes or soundings to a depth of 8100 feet, and if at that depth any reservoirs of water exist, it would be possible for us to draw from the interior of our planet real rivers of boiling water, to imitate on a colossal scale the grand phenomena of the Geysers, and to place incalculable treasures within the reach of human industry, by opening up to it the inexhaustible mechanical force of aqueous vapour—a constant and a comparatively inexpensive supply of that universal motor and regenerator of the world, STEAM. In this direction, if the speculations of our authority be worth anything, we should seek a substitute for that precious mineral which our overworked coal-mines will, before long, refuse to supply.

But, abandoning the dreams of theorists, and returning to the domain of facts, we may reasonably infer, from the data set forth above, that the central mass of the earth is always and invariably in a condition of liquefaction, owing to the effect of excessive heat.

CHAPTER V.

SPRINGS, SOURCES, AND FOUNTAINS.

Origin of Springs—From Lucretius—Phenomena of rain—Explanatory remarks—Capriciousness of rain—Statistics of the rainfall in different localities—Water and scenery—The Fountain of Arethusa—A legend—Palestine a “land of springs”—The course of streams—Springs in the granite formation—Fountain of Vaucluse—Fountain of Nîmes—St. Winifred’s Well—Fets and wells—Fresh-water springs out at sea—Intermittent springs—Siloam—Mineral springs—Carlsbad—Kissingen—Vichy—Barèges—Aix-la-Chapelle—Spa—The German baths—Baths in the Pyrenees—Hot waters of Bath—Tunbridge Wells.



HOSE springs and fountains which add so greatly to the beauty of the terrestrial landscape, and are so essential to the health and comfort of man, issue from reservoirs concealed in the bosom of the rocks. These reservoirs are kept supplied by the showers, and dews, and mists, and melting snows, produced by the variations and circulation of the atmospheric currents. Enormous masses of vapour are in continual movement; ascending and descending, now accumulating and now dispersing, now scattering and now condensing; but all finally pouring their fertilizing currents into the womb of earth, and quickening the growth of its vegetation. The important part which they play in the economy of nature has been well described by Lucretius:—

** Postremo pereunt imbres : ubi eos pater æther
 In gremium matris terræ præcipitavit ?
 At nitidæ surgunt fruges, ramique virescunt
 Arboribus : crescunt ipsæ, fœtuque gravantur.
 Hinc alitur porro nostrum genus atque ferarum,
 Hinc lætas urbes pueris florere videmus,
 Frondiferasque novis avibus canere undique silvas."

At length the rains depart : whither, O say,
 Into the womb of mother Earth has Heaven
 Precipitated quick their genial wealth ?
 But see the glowing grain once more appears,
 Once more the boughs grow green with leafiness ;
 They flourish fair, they droop with heavy fruit.
 Hence does the human race, hence, too, the brutes
 Their sustenance derive ; and hence the towns
 Are joyous with the hum of youth, while loud
 The woods resound with songs of new-born birds.

We have elsewhere written, and may now repeat, that if the reader would fully understand the phenomena of Rain,—phenomena of such infinite importance to the wellbeing of the animal world, and without which the earth would speedily be converted into a drear and lifeless wilderness,—he must bear in mind a few primary principles :—

1st, That an uniform temperature of the atmosphere would necessarily be fatal to the production of dew, rain, snow, or hail ; because the water absorbed by it in evaporation would incessantly descend in an imperceptible vapour, or, when the air was fully saturated, would cease to be absorbed.

2nd, That the absorbent and retentive properties of the atmosphere are greater in warm than in cold air.

3rd, That the air is warmest which is closest to the earth's surface.

Every mountain-climber knows that the higher he ascends the greater becomes the rarefaction, and conse-

quently the coldness, of the atmosphere. Now when, from continual absorption, the air is charged with vapour, if its temperature be suddenly lowered by the influence of a cold current descending from the higher strata, or coming from a high to a low latitude, its capacity of retaining moisture will be diminished, clouds will gather, and rain will fall. Air condenses as it cools; it resembles a sponge filled with water, which, vigorously compressed, gives out the moisture its diminished capacity can no longer retain.

Thus simple, and yet beautiful, is the philosophy of Rain; of rain which fertilizes our pastures and corn-fields, gives bloom and freshness to our flowers, invests the trees in their glorious garb of foliage, and feeds our springs with their living waters. How black, how barren were the earth without it! How all the beauty of colour and all the poetry of growth would disappear from the monotonously sterile landscape! How deep a depression would paralyze the mental and physical faculties of man, even supposing that, under such altered conditions, he could exist at all! The glory and the life and the music of the world depend upon the regular recurrence of the phenomena we have attempted to describe.

With these reflections present to his mind, the reader will all the more keenly appreciate the melody and significance of the following passage:—

“ The poet can behold
Things manifold
That have not yet been wholly told,
Have not been wholly sung or said.
For his thought, that never stops,
Follows the water-drop

Down to the graves of the dead,
Down through chasms and gulfs profound
To the dreary fountain-head
Of lakes and rivers under ground ;
And sees them, when the rain is done,
On the bridge of colours seven
Climbing up once more to heaven,
Opposite the setting sun.

" Thus the sun,
With vision clear,
Sees forms appear and disappear,
In the perpetual round of strange,
Mysterious change
From birth to death, from death to birth ;
From earth to heaven, from heaven to earth."

In considering the phenomena of Rain, however, we must not forget its apparent capriciousness. We say apparent, for no doubt it is governed by fixed laws, though modern science has not yet detected them. In certain parts of the world, which the physical geographer has christened *Rainless Regions*, the welcome shower is seldom seen. Such is the case in the valley of the Colorado and Columbia, in North America ; on the Peruvian coast of South America ; in the Great Sahara of Africa ; and the deserts of the Great Gobi, in Central Asia. On the other hand, in certain localities, as in Patagonia, the rain falls almost daily, and nature thus preserves an equilibrium.

The quantities which descend in temperate climates are curiously irregular, differing greatly in successive years. They differ also at places situated within a comparatively short distance of each other. Thus, in England, a rainfall amounting to one inch per diem is considered very heavy ; yet, in the Scottish Highlands, it will often exceed three inches. It is recorded that on

the 5th of December 1861, $12\frac{1}{2}$ inches fell at Portree, in the island of Skye, in thirteen hours. On the 27th of November 1845, at Scathwaite, in Cumberland, 6.62 inches fell.

The heaviest rainfall occurs, of course, in tropical regions; but there, as elsewhere, it is affected by local conditions, such as the presence or absence of mountains, forests, swamps, lakes, or great rivers. It is modified also by careful drainage. The maximum for the whole world is found on the Khasia Hills, where it reaches the tremendous amount of 600 inches in a twelve-month. At twenty miles in the interior it sinks, however, to 200 inches; at Gowadaly, in Assam, to 80 inches. It does not exceed 75 inches at Bombay; 45 inches at Madras; and 24 inches at Seringapatam. From the following table the irregularities of this phenomenon will be very clearly seen:—

Annual Rainfall in Inches.	Annual Rainfall in Inches.
Vera Cruz, South America.....183	Mobile, Alabama, United States.. 64
St. Benoit, Isle of Bourbon.....163	New Orleans, United States..... 52
Caraccas, South America.....155	Fort Vancouver, British Columbia 47
Island of San Domingo.....107	Valley of the Rhine..... 30
Pernambuco.....106	Great Britain, west, inland...30 to 45
Georgetown, Demerara.....100	Do. do. east, inland.....20 to 28
Sierra Leone, Africa..... 87	Do. do. lake districts..85 to 150
Canton, China..... 78	France, Nantes..... 51
Barbadoes, West Indies..... 72	France, average of the whole
The Bahamas, West Indies..... 52	country..... 30

A portion of the water which descends in the shape of dew, rain, or hail, is evaporated anew by the terrestrial or solar heat; another portion trickles along the surface, accumulates here and there in pools, which gradually percolate through the soil, or descend the slopes in tiny rills. Penetrating into the earth eventually, at variable

depths, it collects in subterranean sheets, which make their way between the superimposed strata. These sheets of water lie sometimes very near the surface. At Paris, for instance, it is impossible to excavate eighteen or twenty feet deep without coming upon it; and the construction of sewers beneath the streets of the metropolis necessitates, as a preliminary operation, the exhaustion of all the aquiferous strata.

To the same cause we must look for an explanation of the origin of *Springs* or *Natural Fountains*. These, in fact, are simply the pluvial waters accumulated in subterranean ducts and courses, and emerging into the light at a point below their first level. The waters furnished by the springs, and the superficial or drainage waters, give birth to *brooks*, which, in their turn, are the parents of *streams* and *rivers*.

The two last-named terms are indifferently applied to water-courses of some considerable volume. The borders of a running stream are called its *banks*; the right and left bank being on the right and left hand respectively of a spectator standing at the source, and looking towards the mouth. If the bank is steep, it is called a *cliff* or *seam*; a level bank, in Scotland, is named the *haugh*. The *bed* of a river is the space which its waters ordinarily cover. Streams which descend rapidly from rugged mountain-heights are designated *torrents*.

When the waters cannot obtain an outlet, or excavate for themselves a channel, they expand into a *swamp*, *bog*, *marsh*, or *morass*. But if the depressions where they collect are of some depth, they gather into mountain-basins, lakes, or lagoons; and the rapid evaporation, con-

stant influx of springs and brooks, and action of the winds, keeps them in continual circulation.

There can be no question that natural scenery derives much of beauty and picturesque effect from the presence of water. Take, for instance, the scene which the traveller witnesses from the castled height of Stirling, where the entire charm is due to the mazy windings of the silver Forth; the glorious series of pictures presented by the rich valley of the Thames; the romantic attractions of the dales and ravines watered by the Dove; the



LAKE SCENERY IN THE SCOTTISH HIGHLANDS.

splendour of the Scottish or Cumbrian Highlands, with their silver-shining lakes. Those threads of "argent sheen" which uncoil, like glistening ribbon, from the chinks and fissures of the rock; those broader belts which traverse fertile meadows and wind round swelling hills,

form the most pleasing, if not the most poetical, features of a fair landscape. The transparency of their waves, the musical sweetness of their continuous flow, and the luxuriant verdure which tracks their fertilizing and brightening course, exercise a very subtle influence on the brain and heart of man. Hence the almost sacred associations which cling to so many famous streams and fountains. Who has not heard of Hippocrene, situated at the foot of the haunted slopes of Mount Helicon ? Or of

“ The inspired Castalian spring,”

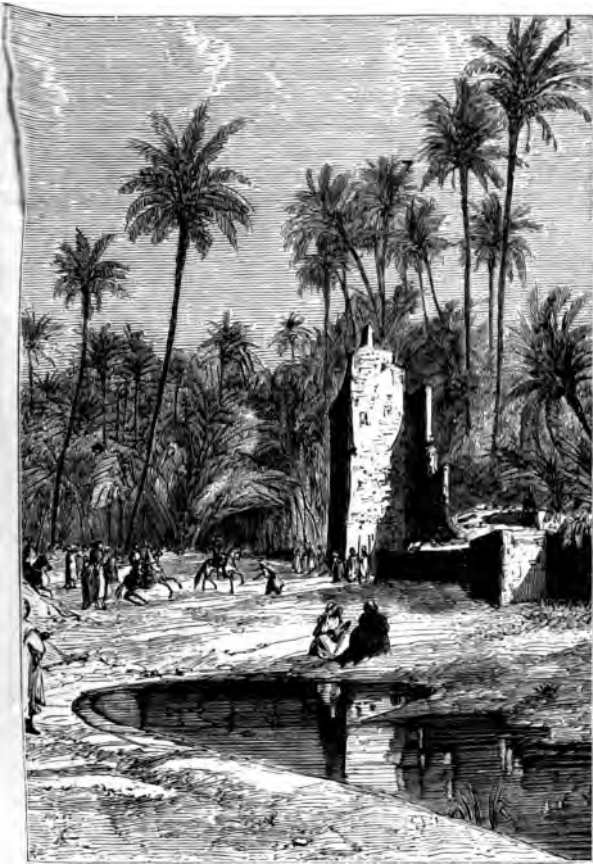
in the mysterious valley of Parnassus, from which the Pythoness of Apollo’s temple drew her inspiration ? The fountain, immortalized by so many memories of classic Greece, is now dedicated to St. John ; near its brink a small chapel has been erected ; and a fig-tree, surrounded by bushes and thick grasses, overshadows its basin.

To the nymph Arethusa several of the fountains of antiquity were consecrated. At that which shines and bubbles in the picturesque island of Ithaca the flocks of *Odysseus* quenched their thirst. “ Go,” said the goddess *Calypso* to the hero, when on the point of returning to his island-kingdom—“ go, and first find the peasant who guards the herds near the Coracian rock whence flow the purple waters of Arethusa.” It is situated near the southeastern extremity of the island, at a distance of three leagues from the sea, and consists of a narrow basin, high up in a lofty ravine, supplied by waters which drop from the overhanging rocks. The traveller, seated among the ruins of the temple which formerly covered the spring, beholds the soft slopes of the valley profusely embellished

with large-leaved plants and sweet-scented bushes : beyond, through an opening in the verdurous gloom, his eye catches sight of the sapphire-tinted sea. From the crest of the rock he sees unrolled before him an extended panorama, embracing the blue mountain-peaks and fairy isles of Greece. Into this delightful solitude came, the poet tells us, the wise and wary Odysseus, to rest himself on the margin of the spring, whose waters then, as now, refreshed the Ithacan goatherds. Dr. Dodwell speaks of them as clear, fresh, and pleasant to the taste ; they issue, he says, from a massive rock, still called Korax (Κόραξ). The depth of their basin measures about three feet and a half ; it has been surrounded with a parapet to prevent any waste by overflow. On issuing from an orifice pierced in the enclosing masonry, they fall into a trough intended for the convenience of thirsty cattle. In 1798 the island of Odysseus was in the possession of the French.

Everywhere beneficent, springs acquire a singular importance in the barren deserts of Africa ; where, in the dreary solitude, they give life and freshness to those verdant islands which are called *oases*. In the pages of Holy Writ we read of the fountains of Marah and Elim, in the desert of Arabia, whose brackish waters the Israelites sweetened in the manner still familiar to the Arabs, by infusing into them the juice of certain plants.

Dean Stanley describes Palestine as a land of springs ; a land of brooks of water, of "fountains" and "depths" that spring out of "plains" and "mountains." Its abundance of water, both from sources beneath the surface,



OASIS IN THE AFRICAN DESERT.

and from the clouds which gathered round its mountain-summits, was absolutely peculiar to Palestine amongst all the countries of the East.

“Feeble as its brooks might be,—though, doubtless, they were then more frequently filled than now,—yet still it was the only country where an Eastern could have been familiar with the language of the Psalmist : ‘He sendeth the springs into the valleys, which run among the mountains.’ These springs, too, however short-lived, are remarkable for their copiousness and beauty. Not only not in the East, but hardly in the West, can any sources of streams be seen so clear, so full-grown even at their birth, as those of the Kishon, the Jordan, and the whole of the Jordan valley. Wales and West-



THE SOURCE OF THE JORDAN.

moreland are not regarded as fertile regions ; and the green fields of England, to those who have come fresh from Palestine, seem, by way of contrast, to be indeed ‘a land of promise.’ But transplant Wales or Westmoreland into the heart of the Desert, and they would be far more to its inhabitant than to their inhabitants are the richest spots of England. Far more ; both because the contrast is in itself greater, and because the phenomena of a mountain country, with wells and springs, are of a kind almost unknown to the dwellers in the deserts or iron-plains of the East.”

The beautiful course of a leaping stream has been described by many of our poets, but by none, perhaps, more faithfully and graphically than by Shelley. In the following exquisite passage we seem to see the flash of the



THE NOISY BURN

torrent, and to hear its music, as it descends from its mountain well-head :—

“ Arethusa arose
 From her couch of snows
 In the Acroceraunian mountains,
 From cloud and crag
 With many a jag
 Shepherding her bright fountains.
 She leapt down the rocks
 With her rainbow locks
 Streaming among the streams ;
 Her steps paved with green
 The downward ravine
 Which slopes to the western gleams :

A PASTORAL STREAM.

And gliding and springing,
She went, ever singing,
In murmurs as soft as sleep ;
The earth seemed to love her,
And heaven smiled above her,
As she lingered towards the deep."

How different the career of a stream which flows through a pastoral country; of such a brook as Tennyson has described, which flows on and on with an ever gentle

*A PASTORAL STREAM.*

motion, always bright and clear, always calm and placid, or, at the utmost, breaking out only into little eddies and tiny swirls, when its course is temporarily obstructed by the trunk of a tree or a moss-covered stone !

" I chatter over stony ways
In little sharps and trebles,

I bubble into eddying bays,
I babble on the pebbles.

"With many a curve my banks I fret,
By many a field and fallow,
And many a fairy foreland set,
With willow-weed and mallow."

What a contrast between this equable and tranquil stream, the joy and life of the valley and the meadow, and the noisy, restless, impetuous burn, which tumbles down from the steep hill-side in a succession of foamy falls, and with many a wild and hasty leap, as if it could never accomplish its journey in too brief an interval! There is almost as much variety in the character of streams as in the character of men. Compare the "bourns" of sylvan Hampshire with the "becks" of Yorkshire, or the torrents of the Scottish Highlands, and you will see at once that each has, as it were, a distinct and peculiar idiosyncrasy.

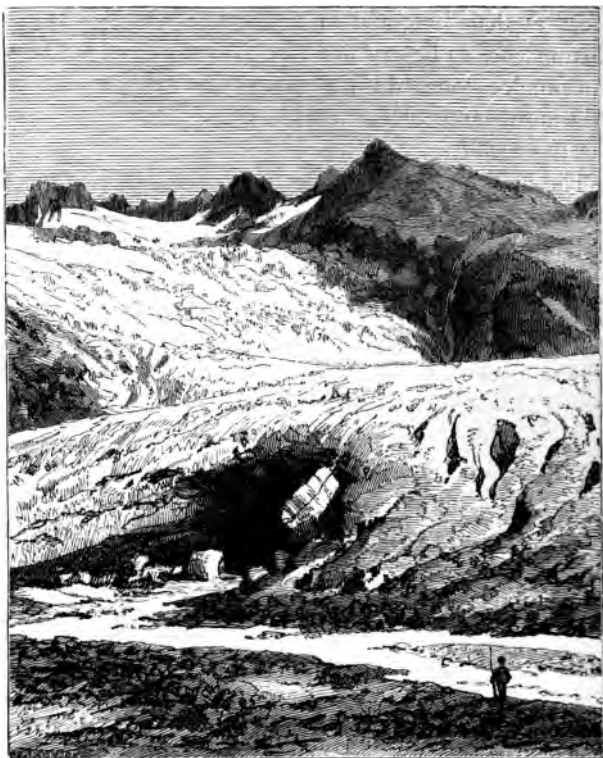
Springs occur in every variety of soil, and at all degrees of elevation; but they are most numerous in the stratified formations, because in these the waters more readily accumulate, and more easily excavate for themselves a subterranean channel. They are generally very numerous in the granite and schistose mountains, but there they are also very feeble. They occur very frequently in the ancient rocks, such as the porphyries and trachytes. Many, for example, well out from the declivities of the Mount Dore chain, making their way to the lower ground in flashing and far-resounding cascades. Though not often seen upon volcanic mountains, they



LAKES OF MOUNT ROSE CENTRAL FRONT.

occur at their base and in their immediate vicinity ; a circumstance to be explained by the porosity of the lava and punice-stone, which admits of the ready transit of the waters, and enables them to find their level with comparative facility.

The number, as well as the relative insignificance of those springs which have their source in the granite, gneiss, and micaceous schist, is due to the infinity of the crevasses and fissures in their strata, which, dividing the infiltrating water into a myriad "threads of crystal," permit it to escape in every direction. Not the less, as the granite peaks are usually of a lofty elevation, do their snow-clad heights give birth to springs of great copiousness, which become the parents of famous rivers. Thus, the Rhine, the Rhone, the Danube, and the Po take their rise in the bosom of the Alps. In the limestone mountains, consisting of soft friable rocks, horizontally stratified, the waters easily penetrate through the vertical fissures, and collect in those subterranean reservoirs or caverns which are so numerous in the limestone formations. The springs which thence arise are invariably of considerable volume, and expand almost immediately into powerful water-courses. Swollen by a hundred tributaries, they broaden and deepen into great rivers soon after emerging from their hiding-places. Such is the case, in the Jura, with the celebrated Loire ; it no sooner issues into the light of day than it supplies human industry with a valuable motive-power. Similar expansive force is shown by the Fountain of Vaucluse, near Avignon, and the Fountain of Nîmes. These belong to the category of inexhaustible springs.



SOURCE OF THE RHONE.

The *Fountain of Vaucluse* is immortal through its associations with the poet Petrarch. It rises at a distance of five leagues from Avignon, and about one thousand yards from the village of Vaucluse. The traveller, desirous of paying a visit to a shrine so famous, enters a narrow valley, hemmed in on either side by rugged precipices,

which gradually close together, until they form a steep and impassable barrier ; hence the name of the valley,



FOUNTAIN OF VAUCLUSE.

Vallis clausa, Vaucluse. At the foot of this barrier rises the famous spring. A score of torrents leap forth and sparkle, dash headlong in noisy rage, and gathering at last into a single channel, form the river Sorgue. Below the barrier lies a circular basin, about seventy feet in diameter, surrounded by large masses of rock, and hollowed

out so as to present the shape of a gigantic funnel, within which the water is maintained at varying levels. It is said that the depth of this natural abyss has never been fathomed. Its excavation extends far under the rocks, and vast subterranean channels conduct to it the supplies resulting from the liquefaction of the snows. The blocks piled up in front of the basin are overgrown with a blackish-green moss, which grows on a white powdery limestone earth deposited by the waters.

On the border of the basin was erected, in 1807, a column, inscribed, "To Petrarch." Though modelled in imitation of the Trajan Column at Rome, its effect appeared so insignificant when compared with the grandeur of the surrounding scenery, and was so dwarfed by the elevation of the immense rocks accumulated in the neighbourhood, that it was thought advisable to remove it. Accordingly it was re-erected at the entrance to the village, where it is still standing.

It was in the delightful retirement of this wave-haunted valley that the poet Petrarch composed several of his immortal works.

"In search," he says, in his *Epistle to Posterity*, "of a retreat which should serve me as an asylum, I found, about fifteen miles from Avignon, a narrow but sequestered and delightful valley, named Vaucluse, in whose bosom rises the Sorgue, the most celebrated of fountains. Enchanted by its numerous charms, I retired thither with my books. My narrative would be too long if I recounted all that I accomplished in this solitude, where I passed a great number of years. I may give the reader an idea of it by saying that of all the works which have proceeded from my pen, not one but was composed, conceived, or begun there; and these works are so many that even now, at an advanced age, they occupy and fatigue me...

"My retreat has inspired me with reflections on the rest and solitary life of the cloister, of which I have recorded my admiration in two separate treatises. Finally, it was among these lonely shades that I endeavoured to extinguish the devouring fire which consumed my youth. Thither I withdrew myself as to an inviolable sanctuary: imprudent that I was! the remedy did but increase my anguish. Meeting with no one, in a solitude so absolute, to assist in staying the progress of the disease, I suffered all the more keenly. And the fire of my heart bursting its bonds, I made these valleys resound with my melancholy cadences, which, according to indulgent readers, are not without a music of their own."

The effect, sometimes majestic, sometimes radiant and picturesque, of the Fountain of Vaucluse, depends upon the alternations which occur in the influx of its waters. At the point of their actual emergence an immense rock rises in one solid continuous mass, overhanging the spectator's head like a threatening thunder-cloud. When the waters are low, he sees at his feet a horrible chasm, only partially filled; when they are high, he has before him a cascade dashing over a succession of ledges in a magnificent sheet of silver, which, as it descends, breaks and shatters into coruscating showers and splinters of spray, with a tremendous roar.

In the ordinary annual inundations, the water is divided into numerous falls of unequal height, which disport among the mossy and lichened crags, and glitter with a thousand rainbows. After heavy rains, however, these swell into a noble river, which precipitates itself from the cliff like a miniature Niagara.

The scene which is generally presented, and which the pen of the poet and the pencil of the artist have done their best to make known to all lovers of natural beauty,

seems described with much fidelity in the following lines, though we are not aware that they were suggested by it:—

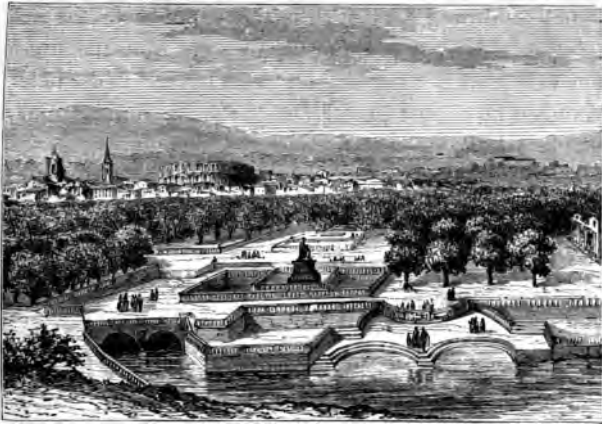
- “ Beside a lofty waterfall I’ve stood,
 Formed by a torrent from a mountain-height,
 And gazed far up to where the foaming flood
 Burst from the sky-line on my awe-struck sight.
- “ So vast its volume, and so fierce its shock,
 No power at first its headlong course might stay ;
 It seemed as if the everlasting rock
 Before its furious onset would give way.
- “ But as it fell, it lingered in mid-air,
 And melted into lace-like wreaths of mist,
 Decked by the sun with rainbow colours fair,
 And swayed by passing breezes as they list.
- “ And when at last it reached the dimpled pool,
 Hid in its granite basin far below,
 Its spray fell softly as the showers that cool
 The sultry languor of the summer glow.
- “ The aspen-leaf scarce quivered to its sound,
 The blue-bell smiled beneath its benison ;
 And all the verdure of the forest round
 A fresher greenness from its baptism won.”

The Fountain of Nîmes, celebrated by Ausonius,—

“ Non Apomeo potu, vitrea non luce Nemausus purior,”—

rises at the foot of a hill about 230 feet high, on whose crest stands the ancient but shattered memorial of antiquity known as the *Tour Magne*, or *Turris Magna*. What purpose it served—whether it was used as a tomb, a pharos, or a watch-tower—antiquaries have not determined.

The waters of the fountain were utilized by the Romans for their public baths, whose masonry may still be seen above the regular basins constructed, in the reign of Louis XIV., with the view of converting the winding and broken banks of the stream into a magnificent orna-



FOUNTAIN OF NÎMES.

mental promenade. To the left of the principal basin lie the ruins of the so-called Temple of Diana.

A charming book might be written on famous springs and fountains, their associations, their legends, and their scenery. We must not here essay the pleasant task, yet we cannot refrain from noticing some of the more remarkable.

St. Winifred's Well, at Holywell, Flintshire, is one of the inexhaustible springs. Its source is to be found in a bed of shingle at the foot of a steep hill, and it rushes forth with such impetuosity as to overflow the upper basin and dash down into another and smaller one beneath. It is overcanopied by a perpendicular Gothic structure, dating from the early part of the reign of Henry VII., which forms a crypt under a small chapel contiguous to the parish

church, and on a level with it, the entrance to the well being by a descent of about twenty steps from the street. The well itself is a star-shaped basin, ten feet in diameter, canopied by a most graceful stellar vault, and originally enclosed by stone traceried screens filling up the spaces between the supports. Round the basin is an ambulatory similarly vaulted.

The ornamental sculpture includes various quaintly carved animals and the rich armorial bearings of the different benefactors of the shrine ; as Catharine of Arragon, Margaret Tudor, and some of the Stuart family.

The stones at the bottom of the well are overgrown with the fragrant *Byssus colithus*, and a species of red *Jungermannia* (Scale-moss), locally known as St. Winifred's hair and blood.

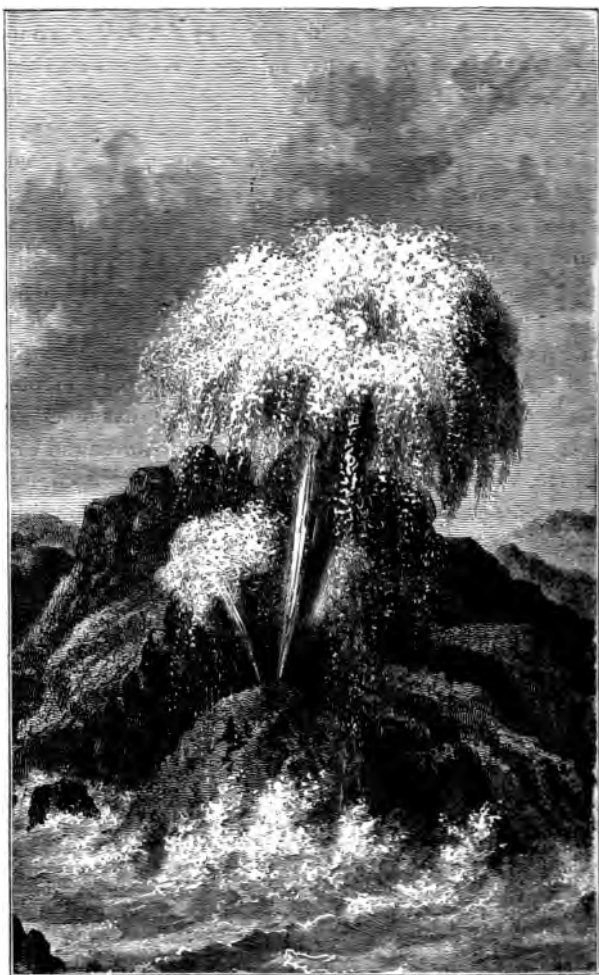
Formerly, the curative properties of the water of St. Winifred's Well were highly esteemed ; and when Pennant visited it, in the last century, he found the crutches of grateful cripples suspended to the vaulted roof as votive offerings. " In the summer," he says, " a few are still to be seen in the water, in deep devotion, up to their chins for hours, sending up their prayers, or performing a number of evolutions round the polygonal well ; or threading the arch between well and well a prescribed number of times. A crowned head," he adds, " in the last age, dignified the place with a visit. The prince who lost three kingdoms for a mass (James II.), paid his respects, on August 29th, 1686, to our saint, and received as a reward the very shift in which his great-grandmother, Mary Stuart, lost her head."

The quantity of water furnished by the well is computed at 21,000 gallons per minute. It flows into the Irish Sea, which is about half a league distant, and in its course supplies the motive power of several mills.

In a recent work on Physical Geography, we read that when the water, descending from a certain elevation, infiltrates through a porous stratum, which is in itself intruded between two impermeable beds, at a gradually rising inclination, it tends to rise vertically, in accordance with a well-known principle of hydrostatics; and if it finds an orifice in the upper stratum, it escapes violently in the form of what is called a "leaping fountain" or "jet." A French writer points out that examples of these "jets" exist in the sources of the Loiret and the Touvre, which come up with a rush and a din from the deep gulfs regarded by the natives as unfathomable abysses. Almost immediately after their emergence into the light of day, these springs have a sufficient volume of water to carry boats. The Touvre, an affluent of the Charente, increases nearly twofold the force and bulk of the latter river. It is formed by three springs, which open in the bed of the ravine at a point about eight miles east of Angoulême. Where these springs meet together, the channel is 320 feet in width by seven feet in depth. Forges and foundries in incessant activity are scattered along its banks.

The following instances are borrowed from the pages of "Earth and Sea":—

At the Castle of Sozay, near Clamecy, occurs a leaping fountain or jet, named the Abyss, which issues from a deep well, about thirteen feet in diameter.



THE BUFFADERO, IN THE GULF OF MEXICO.

On the shore of Alvarado, in the Gulf of Mexico, is a headland of sand, 140 feet high, on whose summit rises a beautiful jet of pure translucent water, known as the Buffadero, from which the vessels of the port obtain their supplies.

Similar fountains are numerous in the peninsula of the Morea.

They are found occasionally rising from the very bottom of the sea, as in the Bay of Jagua, on the genial southern coast of Cuba.

At a distance, says Humboldt, of two or three leagues from the land, fresh-water springs issue in the midst of the salt water ; and their eruption is accompanied by so much violence that it is difficult for small boats to approach, on account of the high rolling waves, which dash against one another with an incessant roar. Sometimes the coasting vessels draw near, however, to take on board a supply of fresh water, which is much sweeter than can be obtained very frequently from wells of an exceeding great depth.

A remarkable example of a fresh-water jet in the midst of the sea is found in the Gulf of Spezzia. The fountain leaps above the waves, and forms a kind of dome, upwards of sixty-five feet in diameter, and from twelve to sixteen inches in height : in the centre numerous vertical jets pour forth their contents with so much impetuosity that a boat can with difficulty be arrested in its course in the midst of their elevation. Spallanzani sounded the depth at one hundred and seventy feet from the shore, and touched the bottom at about eight fathoms.

Many springs, and especially many jets or leaping fountains, possess an intermittent character. This phenomenon is attributed by physicists to the presence of subterranean cavities, in which the water accumulates, to return through canals or ducts curved in the form of siphons.

If the quantity of water *flowing out* exceeds that which is *flowing in* from the upper regions (C, D, E, F), it is obvious that, sooner or later, the level of the reservoir (A) will sink below the top of the siphon ; the spring (B) then ceases to flow until the reservoir is refilled.



THEORY OF THE INTERMITTENT SPRINGS.

These interruptions and resumptions are frequently *periodic*; that is, they take place at regular intervals. Pliny has described the periodical fountain of Como, in Milan, whose intermissions occur hourly. That of the Abbey of Haute-Combe, in Savoy, makes its appearance every twenty minutes, rising in a vertical duct or canal from the interior of the Dent-du-Chat. It is situated about 420 feet above the level of the Lake of Bourget.

The Puits-Gros, at a short distance from Chambéry, flow at sunrise and sunset, noon and midnight ; in other words, every six hours.

The fountain of Boulaigne, near Fressinet, in the Coyrons mountains, sometimes ceases for twenty years ; then it flows for several months, pauses or simply trickles hour by hour, and ends by again disappearing for a considerable period.

The Pool of Siloam is a basin situated at the foot of Mount Zion, in the historic Valley of Jehoshaphat. It is fed by the waters of the Virgin's Well, which descend into it through a subterranean channel. The basin is surrounded by masonry, and measures fifty-six feet long by twenty feet broad. Its overflow serves to irrigate the fruit-gardens scattered along the valley-slopes. This fountain ebbs and flows at regular intervals. Hence the natives pretend that it is inhabited by a dragon, and that it flows only when the dragon is lulled asleep.

According to Dean Stanley, all accounts combine in asserting that the water of the fountains of Siloam proceed from a spring or reservoir beneath the Temple-vaults. There was no period of its history when such a provision would not have been important to the Temple, for the ablutions of the Jewish no less than of the Mussulman worship ; or to the city, which else was dry even to a proverb. It was the treasure of Jerusalem, its support through its numerous sieges,—the *fons perennis aquæ* of Tacitus, the source of Milton's

“ Brook that flowed
Hard by the oracle of God.”

But, more than this, it was the image which entered into the very heart of the prophetic idea of Jerusalem. It is the source of all the beauty and freshness of the



THE POOL OF SILOAM.

vale of Hinnom. And in Ezekiel's vision, adds Dean Stanley, the thought is expanded into a vast cataract flowing out through the Temple-rock eastward and westward into the ravines of Hinnom and Kidron, till they

swell into a mighty river, fertilizing the desert of the Dead Sea.

The writers of antiquity, and even some of our modern philosophers,—among others, Descartes,—adopted the theory that all springs were due to the penetration of the ocean-waters into subterranean cavities. When collected in these reservoirs, they are heated by the action of the central fire and reduced into vapour, which, making its way into the upper strata, are there condensed, whereupon they gather into springs and fountains, and emerge into the light of day. Surely none but a dreamer could have taken the trouble to evolve so gratuitous and unenable a theory!

The *true* origin of the subterranean waters was suspected by Bernard Palissy, who, in his book, “*Sur les Eaux et Fontaines*,” observes, that the reason more rivers and fountains proceed from mountains than from all the rest of the earth, is simply because the mountain-rocks retain the rain-waters, just as a vessel of brass might do; and the said waters, percolating through chinks and fissures, continually sink without encountering any impediment, until they reach some bed of stones and pebbles, lying closely compacted and in a solid mass; upon this bottom they repose, and having at last discovered a duct or channel, issue forth in fountains, or in brooks and rivers, according to the dimensions of the canals and reservoirs.

Mineral springs are those which hold in solution certain definite quantities of mineral substances with which they have become charged during their subterranean course.

They are frequently divided into four classes: namely—

- I. *Saline*—as those of Karlsbad and Kissingen ;
- II. *Alkaline*—as those of Vichy and Töplitz ;
- III. *Chalybeate*—as those of Bath, Spa, and Pyrmont ;
and,
- IV. *Sulphurous*—as those of Baréges and Aix-la-Chapelle.

A brief description of some of the more remarkable may prove both useful and interesting to the reader.

Carlsbad, or Karlsbad—"Charles's Bath"—derives its name, it is said, from the circumstance that its waters were discovered, or, if not discovered, were popularized, by the Emperor Charles IV. While enjoying the pleasures of the chase in the neighbourhood, he was attracted to the spot by the cries of a hound which had fallen into the hot waters of the Sprudel in pursuit of a stag.

The emperor was suffering at the time from the effects of wounds received at the battle of Crécy, from the cloth-yard shafts of the English archers. His physician, Peter Bayer, induced him to test the curative properties of these waters; and he benefited so greatly by them that, out of gratitude, he bestowed important privileges on the adjacent town, and permitted it to assume his imperial name.

Carlsbad lies at the bottom of a rocky and well-wooded valley, on the margin of the small stream of the Tepl (*teply*, "warm"). About the centre of it, by the river-side, a cloud of vapour may be seen continually ascending. This cloud indicates the site of the hottest mineral spring in Europe,* the *Sprudd*, which springs up into the air in several jets, to a height of four or five feet. Its temperature is equal to 165° F. Its water boils eggs hard, and the townspeople use it to scald their poultry and pigs. Its principal mineral ingredients are sulphate of soda, carbonate of soda, and chloride of sodium. It also contains small quantities of bromine and potash. As it holds in solution a large amount of carbonate of lime, which quickly encrusts every object brought into contact with it, the Sprudel may also be regarded as a *petrifying spring*. All the

* The Geysers of Iceland are, of course, excepted.

surrounding rocks, and the valley-slopes for a considerable distance, are covered with a stratum of tufa, the accumulated deposit of the mineral waters.

There are several other springs: for instance, the *Mühlbrunnen* (127° F.), the *Neubrunnen* (147° F.), the *Theresienbrunnen* (123° F.), and the *Schlossbrunnen* (118° F.). In fact, it may be said that Carlsbad stands on the lid of a vast caldron of boiling water, the vapours of which would burst and destroy the town, did not the natural outlets to which we have alluded permit them to escape. They are not found, however, to be sufficient, and several large holes have been bored through the rock in various parts of the town as safety-valves, or as additional shafts are provided for a coal-mine. The extent of the subterranean reservoirs may be inferred from the fact that the quantity of water which flows from the springs daily is estimated at 2,000,000 gallons.

Kissingen.—At Kissingen, in Bavaria, the mineral springs are three: the *Rakoczy* and *Pandur*, which are saline and chalybeate; and the *Maxbrunnen*, which is acidulous and alkaline.

In the neighbourhood is an important brine spring, the *Soolens-purdel*, which ebbs and flows at regular intervals, and discharges great quantities of carbonic acid gas. The *Schönbornsbrunnen* is another intermittent spring, which ebbs for three or four weeks, and then flows for about the same period. An Artesian well has been sunk to a depth of nearly 2000 feet to reach it, and the water rushes up the shaft in a column of about six inches diameter to a height of nearly eighty feet.

Vichy.—Within the last few years the baths of Vichy acquired a celebrity through the frequent visits paid to them by the late Emperor of the French.

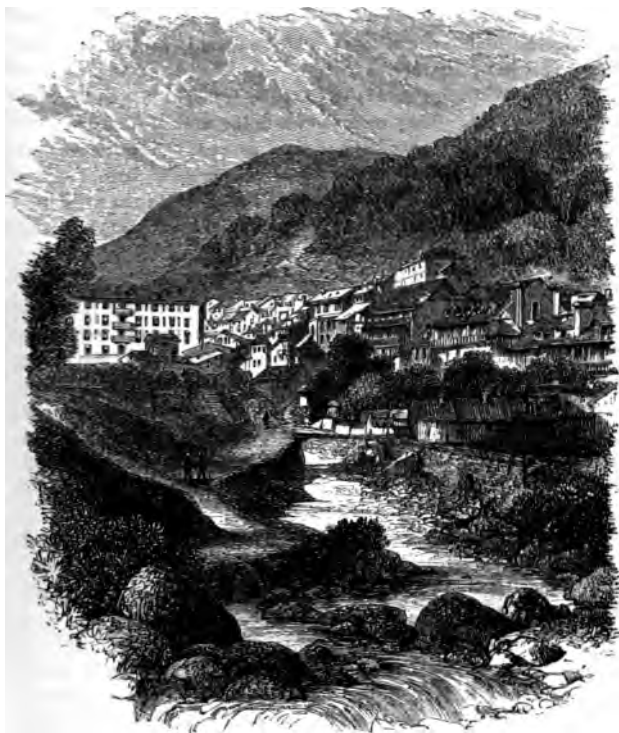
The town is situated on the banks of the Allier, in a sheltered and very agreeable valley. Its mineral springs are acidulous and alkaline, and their principal ingredients are potash, lime, carbonate of soda, and carbonic acid gas. They are described by Dr. Macpherson as peculiarly efficacious in chronic complaints of the liver and digestive organs, in gout, gravel, and enlargement of the liver. The principal springs are as follows:—

Name of Spring.	Temperature.		Grains of Bicarbonate of Soda in each Pint.	
Grande Grille,		107°.5		44
Puits Chomel,		113°		45
Puits Carré,		113°		45
L'Hôpital,		88°		45.50
Lucas,		73°.50		45.50
Lardy,		77°		39
Brosson,		74°.5		44
Celestins,		57°		50
Hauterive,		69°		
Mesdames,		61°		

Barèges is one of the numerous Pyrenean watering-places which have sprung into reputation within the last thirty years, and which have been so frequently described in our periodicals and newspapers, as well as in works of greater pretensions, that the general reader is perfectly familiar with their characteristics. It is the loftiest of the Pyrenean Baths, being situated at an elevation of 4085 feet. Its mineral waters are exceedingly strong, and contain, in various proportions, sulphuret of sodium, carbonate, muriate; and sulphate of soda, and azotic and sulphuretted hydrogen gases. There are seven different springs, but the strongest is *Le Tambour*. The waters are of a greenish-yellow hue, and have that peculiar smell of rotten eggs which sulphuretted hydrogen invariably communicates. After standing awhile, they assume a superficial film of glairy unctuous matter, which the chemists call *Barégine*.

Barèges was first brought into notice by Madame de Maintenon, who visited it in 1676, by advice of the royal physician Fagon, for the sake of her pupil, the young Duc du Maine, natural son of Louis XIV. He was greatly benefited by the waters.

Aix-la-Chapelle, the German *Aachen*, is the capital of a district in Rhenish Prussia. Few cities in Europe are richer in historical associations. Here the illustrious Charlemagne founded his imperial palace in 796, or rebuilt and enlarged the edifice erected by his father Pepin. Here the great emperor was buried, in 814. The town, springing up around the splendid structure, rapidly increased in population and prosperity, and in the Middle Ages numbered upwards of one hundred thousand inhabitants. The rulers of the Holy Roman Empire were crowned here, from Louis the Pious to Ferdinand I. (813-1531 A.D.); and seventeen imperial



BAREGES.

diets and eleven provincial councils were held within its walls. It has also been the scene of several congresses which have greatly influenced the political fortunes of Europe. The war between France and Spain for the possession of the Spanish Netherlands was terminated by the first treaty of Aix-la-Chapelle. The second, in 1668, marked the first great check received by Louis XIV. in his schemes of universal conquest. The third, in 1748, concluded the disastrous War of Succession ; and the celebrated congress of 1818

regulated the affairs of Europe after the fall of the first Napoleon, and established an order of things which endured, with little modification, for half a century.

The *Mineral Springs* of Aix-la-Chapelle are eight in number: six hot, and two cold. They were known in the time of Charlemagne, and much frequented at as early a date as 1170. The hot springs are strongly sulphureous, and vary in temperature from 111° to 136° F.—the *Kaiserbad*, or "Emperor's Bath," being the principal. They are described as greatly efficacious in cases of gout, rheumatism, and cutaneous affections.

Spa.—The famous watering-place of Spa is situated in a romantic valley of the Ardennes, about twenty-seven miles to the south-east of Liege. Its mineral springs, seven in number, are all chalybeate, and contain minute quantities of iron, so mingled with alkaline salts and carbonic acid gas as to be both easily digestible and agreeable. Spa was in repute as a watering-place as early as the fourteenth century, and its name has been bestowed on many mineral springs.

Töplitz, or *Teplitz*, one of the pleasantest and most famous of German "spas," is situated on the Saubach, sixteen miles north-west of Leitmeritz. There are eleven hot alkalo-saline springs, the chief of which has a temperature of 120° F.

The German "Baths."—Germany, and more particularly South Germany, may be called the Land of Spas. Their number is legion; and there is scarcely an ill that flesh is heir to which their waters are not reputed to cure. Among the most celebrated we may name those of Bormio, Gastein, Ischl, Marienbad, and Wildbad.

Bormio is situated in the Tyrol. Its springs are hot and sulphureous, with a temperature of 28° and 38° R.

Wildbad-Gastein, or *Bad-Gastein*, in Austria, is a small and picturesque village of forty houses, scattered irregularly and one above the other over a steep slope occupying the centre of a romantic valley, or rather ravine, shut in on either hand by wooded acclivities. The landscape is wild and beautiful in all its details,

and derives an air of grandeur from the roar and splendour of the torrent Ache, which, in a succession of headlong falls, descends an elevation of fully three hundred feet.

Gastein is situated 3347 feet above the level of the sea; but its climate is not so cold as might be expected, owing to its sheltered situation. It is safe from the rude assaults of all winds except the south, so that its mean annual temperature is as high as 41° F., while, in the summer, the thermometer shows an average of 55°.5 F.

It is said that its mineral springs were known in the seventh century. In the fifteenth their renown was revived by that singular combination of the chemist and the quack, Paracelsus; and they are now visited by health-seekers from all parts of the world, and especially by the nobles of Austria, Hungary, and Russia.

There are six hot springs, which rise out of granite-rocks at the foot of the Grankogel. One of them leaps forth from the very bed of the Ache, in the middle of the cataract; and they yield 100,000 cubic feet of water in four and twenty hours. At the fountain-head the temperature is 117°.5 F. Their principal ingredients are carbonate of lime and Glauber salt. Their operation is described as generally exciting, by their stimulating effects on the vascular system or on the skin, where they not unfrequently produce an eruption.

Marienbad is situated about twenty-five miles from Carlsbad. Its reputation is comparatively recent, having been acquired since 1810. Its mineral springs are of two different kinds: two saline-purgative—namely, the *Kreuzbrunnen* and the *Ferdinandsbrunnen*; three chalybeate—namely, the *Carolinenbrunnen*, the *Ambrosiusbrunnen*, and the *Marienbrunnen*. The latter afford us a striking illustration of the activity which prevails “beneath the surface.” They evolve enormous quantities of carbonic acid gas; and gas-baths have therefore been established, in which an original kind of apparatus directs a stream of gas to any part of the body afflicted with disease.

Baths in the Pyrenees.—It has been remarked, with much justice, that the bounty with which Nature has poured forth, throughout

the whole range of the Pyrenean mountains, mineral sources of healing quality, and of various kinds, is truly surprising, and forms an interesting natural phenomenon. It has been calculated that in the whole chain there are no fewer than two hundred springs, many of them at a high temperature; and it would seem that they usually emerge near the junction of the Primitive or igneous rocks, as granite, gneiss, or porphyry, with some Secondary formation, chiefly limestone.

The principal are those of Eaux-Bonnes, Eaux-Chaudes, Caunteretz (immortalized by Tennyson*), St. Sauveur, Barèges (which we have already described), Bagnères de Bigorre, and Bagnères de Luchon.

Before we quit the subject of Thermal Springs, we must direct the reader's attention to the most celebrated of those which are found in the British Islands—the "hot waters" of Bath.

Bath.—The legendary origin of Bath is thus related by the local historians:—Once upon a time lived Prince Bladud, the eldest son of Lud Hudibras, King of Britain. Through some undescribed fatality, he became a leper, and as his disease was contagious, and was then considered incurable, his father reluctantly exiled him from his court. Wandering to and fro, in great necessity and sorrow, the young prince was at length reduced to hiring himself out to a swineherd at Keynshams. In the discharge of his duties he seems to have communicated his leprosy to the herd under his care; and to avoid the indignation of his master, he drove the infected swine to the neighbouring downs, which, in those days, were extensively clothed with forests. The animals soon found their way to the valley beneath, and, guided by instinct, wallowed luxuriously in the steaming mud-bath formed by the overflow of the hot springs. Bladud, after no light exertions, enticed them from the vaporous swamp, and on releasing them from their incrustation of mud and mire, was surprised to find them greatly improved in appearance, and many of

* In his lines entitled, "In the Valley of Caunteretz," beginning,—

"All along the valley, stream that flashest white,
Deepening thy voice with the deepening of the night."

them entirely cured. Bladud made all haste to test in his own person the value of this natural remedy, and with a similarly good result. A complete cure was effected; and the young prince, returning to his father's court, was received with the welcome due to an heir-apparent. In gratitude for his happy cure, he built a city in the valley of the Hot Springs, which he embellished with temples, palaces, and baths, and where, in due time, he reigned with great magnificence.

The true founders of Bath, however, were the Romans, who, of all the ancients, were the only people fully sensible of the curative and sanitary properties of the thermal resources of Nature. Ptolemy the geographer, writing about A.D. 150, refers to the place under the name of *Tðara Θερμα* (*Aquæ Calidæ*, or Hot Springs), and places it south of Ischalis, the modern Ilchester, in lat. $53^{\circ} 40' N.$, and long. $17^{\circ} 20' W.$ In the *Itinerary* of Antoninus it is called *Aquæ Solis*. Numerous Roman remains have been discovered here; and abundant evidence exists that during the Roman period it was a place of considerable importance, embellished with many handsome buildings.

The *therma*, or baths, erected by the Romans, were evidently of a very splendid description. The remains were discovered and laid open in 1755. Their site apparently extended over the ground now occupied by Abbey Street, with Church Street on the east, and the Abbey Green on the south.

The buildings consisted of a centre and two wings, and included: first, a bath, running north and south, measuring 43 feet in length, and 34 feet in breadth, enclosed within walls eight feet in height, built with wrought stone, lined with terra cotta, and ornamented with twelve pilasters; second, a semicircular bath to the north of the former, measuring from east to west fourteen feet ten inches, and ornamented with four pilasters; third, two spacious *sudatoria* to the eastward, with double floors, on the lower of which stood two rows of pillars composed of square bricks, sustaining a second floor of tiles, thickly coated with cement. The stones and bricks showed evident marks of fire, and the flues were thickly encrusted with soot. One of the furnaces which heated these hypocausts was still visible; and at its mouth lay scattered fragments of charcoal and burned wood.

Succeeding excavations brought to light another semicircular bath to the southward, which, in its main particulars, resembled the one already described. Hence it is conjectured that the whole establishment occupied an area of 240 feet from east to west, and 120 feet from north to south; and it was evidently enriched with all the architectural decorations known to the Romans.

About 576, Aquæ Solis fell into the hands of the Saxons, who named it *Hat Bathan*, and founded here, in 775, a college of secular canons. It suffered severely from repeated incursions of the Danes; and it was not until early in the twelfth century that it began to lift its head above the ruin which had overtaken it. The good reputation of its waters, however, died out, and they had to be rediscovered in the seventeenth century. Queen Anne visited them several times during her short reign; and under George I. they became "the fashion." The town was enlarged and embellished so as to make it a fit residence for its aristocratic patrons; and a code of laws for the regulation of its assemblies was drawn up by that self-appointed *Arbiter Morum*, the notorious Beau Nash. It is now one of the handsomest and healthiest of English cities, and its splendid mansions are not unworthy of the beautiful landscapes which surround them.

The Bath waters rise in four distinct springs, which form respectively the reservoirs and feeders of the King's Bath, the Hot Bath, the Cross Bath, and the Kingston Bath. The first-named yields a supply of 346 tons in rather less than eleven hours, or 126 gallons per minute, with a temperature of 116° at the mouth. It evolves a combination of 97 per cent. nitrogen, 3 oxygen, and a variable quantity of carbonic acid, at the rate of 267 cubic inches per minute. The temperature of the Hot Bath equals 120° F. That of the Cross Bath, 98° F. The principal ingredients are sulphate of lime, chloride of sodium, chloride of magnesium, sulphate of soda, and very minute quantities of iron, alumina, silicic acid, and iodine.

From Bath we ask the reader to accompany us to the most popular chalybeate springs in England—those of

Tunbridge Wells.—In point of antiquity, Tunbridge Wells, as a watering-place, ranks second only to Bladud's city. It occupies the slopes and head of a picturesque valley of the Weald, which is watered by a pretty streamlet on its course to the Medway. Its views are broad, romantic, and diversified; its position is eminently picturesque. Three parishes meet here, Tunbridge, Frant, and Speldhurst; two counties, Kent and Sussex; and the remains of three ancient forests, Bishop's Down, Water Down, and South Firth.

The "wells" are chalybeate, clear, bright, pungent, and not too powerful. They were first discovered by Dudley Lord North, about 1606; and his shattered frame having been completely recruited by them, he published a book in which he extolled them above the "Spa in Germany," and warmly commended their curative properties. They must long previous to his visit have been known to the peasantry, for a common tradition attributed their taste of iron to the devil, who, after a personal combat with St. Dunstan at Mayfield, in which the saint had tweaked his nose with his red-hot tongs, had made haste hither to bathe his afflicted feature in the cool and then tasteless waters. According to another tradition, the chalybeate flavour was imparted by the saint, who finding that the devil's nose had heated his tongs to an inconvenient degree, dipped them in the spring at this place.

Thanks to Lord North's panegyric, the waters soon acquired a considerable reputation, and were visited more than once by Queen Henrietta Maria and her lords and ladies. They rose into astonishing popularity in the reign of Charles II. At that time, there was no town; but within a mile of the spring, rustic cottages, somewhat cleaner and neater than ordinary cottages, were scattered over the heath. "Some of these cabins," says Macaulay, "were movable, and were carried on sledges from one part of the common to another. To these huts, men of fashion, wearied with the din and smoke of London, sometimes came in the summer, to breathe fresh air and to catch a glimpse of rural life. During the season a kind of fair was daily held near the fountain. The wives and daughters of the Kentish farmers came from the neighbouring villages with cream, cherries, wheat-ears, and quails. To chaffer with them, to flirt with them, to praise their straw hats and tight heels, was a refreshing

pastime to voluptuaries sick of the airs of actresses and maids of honour. Milliners, toymen, and jewellers came down from London and opened a bazaar under the trees. In one booth the politician might find his coffee and the *London Gazette*; in another were gamblers playing deep at basset; and on fine evenings, the fiddles were in attendance, and there were morris-dances on the elastic turf of the bowling-green."

Tunbridge Wells is still one of the most popular of our watering-places.

CHAPTER VI.

GROTTOES AND CAVERNS.

Celebrated caverns—That of Trophonius—Description by Pausanias—Mystic ceremonies—The famous oracle—Livadhia—Grotto of the Cumean Sibyl—The Blue Grotto at Capri—Grotto of St. Rosalia—Grottoes with religious traditions—Caves always used as places of retreat and sanctuary—Grottoes of Spagari—Caverns in France—Grotto of Longara, in Italy—Grotto of Camoëns, at Macao—Salt-mine caverns of Wieliczka—Fingal's Cave—Grotto of the Cheeses—Cave of Petchabury—Grotto of Monsummano—Grotto of La Madeleine—Marine grottoes and caverns:—Caves of Crozon—Cave of Morgatte—Grottoes of Etretat—Grotto of Bonifacio—Grotto of Torghatten—S. Michael's Cavern—Scratchell's Cave—Grottoes of Tourane—Caves produced by subterranean currents:—The Devil's Hole—Grotto of Adelsberg—Grottoes of Sassenage—Sundry caverns excavated by subterranean currents—Natural bridges—Stalactitic grottoes:—Antiparos—Grotto of La Bausne—Grottoes of Arcy—Grottoes of Osselles—Grotto of Han-sur-Lesse—Mammoth Caves of Kentucky—Alabaster cavern of California—Grottoes and caverns with concretions not calcareous—Their origin—Ice-caves and natural glaciers—At the abbey of Grace Dieu—Ice-cave of Vergy—Artificial ice-cave of St. Ouen—Bone-caves:—In England—In France—In Belgium—Germany—Caverns in which human bones have been exhumed.



E propose, in this chapter, to describe the most celebrated of the Grottoes and Caverns of the world, celebrated either through their legendary and historical associations, or their natural phenomena.

THE CAVE OF TROPHONIUS.

One of the most ancient, the Cave of Trophonius, formerly famous among the principal oracles of Greece,

is situated near Livadhia (Lebadeia), in Bœotia. Some-
curiously interesting details respecting it are given by
Pausanias.

But, first, the reader may ask, Who was Trophonius ?
We reply, in Greek mythology, the son of Erginus, king
of Orchomenes, according to some authorities ; son of
Apollo, according to others. In common with his
brother Agamedes, he acquired great celebrity as an
architect, and many were the temples of gods—among
others, that of Apollo at Delphos—and the palaces of
kings which sprang from his prolific brain.

It would seem, however, that both Trophonius and
Agamedes were more famous for genius than probity.

Having been commissioned by Hyræius, king of
Orchomenes, to build up a stately pile in which he might
accumulate his treasures, they so accomplished their
work, says Pausanias, as to leave a particular stone re-
movable in the exterior masonry ; and by means of this
opening they were able, whenever they chose, to help
themselves to the precious articles therein deposited.

As Hyræius could not understand how it happened
that, while bolts and seals remained intact, his treasure
diminished daily, he set some snares or traps upon the
vessels containing his gold and silver, to detain the
robber who entered and carried off the spoil.

By this device Agamedes was taken ; and Trophonius
could think of no better scheme than to cut off his
brother's head, partly to deliver him from the cruel
tortures he would otherwise have been doomed to suffer
on being discovered, and partly also to ensure his own
escape.

This cruel but energetic resolution did not prove of much advantage to Trophonius: the ground opened beneath his feet shortly afterwards, and swallowed him up at Lebadeia, in the sacred grove which thenceforward bore his name, and at the spot where is now pointed out "the ditch of Agamedes."

As some compensation for his hard fate, Apollo granted to the skilful architect of his Delphian temple the gift of foretelling the future in the very chasm or excavation wherein he had been engulfed.

After remaining long unknown, this oracle was discovered by the Bœotians, if Pausanias may be believed, in the following manner:—

"For two years there had been no rain in Bœotia. In their despair, the Bœotians sent a deputy from each of their towns to Delphi, to beseech Apollo to put an end to the drought. The Pythoness ordered them to address themselves to Trophonius at Lebadeia, and assured them they would certainly obtain from him a remedy for their ills. Accordingly they went to Lebadeia, but could not discover the oracle they were in search of. During their perplexed inquiries, Saon, from the town of Acroephium, the most advanced in years of all the deputies, caught sight of a swarm of bees, and conceived the idea of following them whithersoever they went. Suddenly he saw them direct their flight towards a mysterious grotto, which he entered with them: the oracle was found! It is said that Saon was instructed by Trophonius himself how to regulate the details appertaining to his *cultus*, and the ceremonies relative to the oracle."

We may briefly sketch the various rites through which

the novice passed who desired admission into the prophetic grotto.

First, he was required to spend a certain number of days in an edifice specially consecrated to the Good Genius and to Good Fortune. There he purified himself by frequent ablutions in the river Hercyna, and by abstaining from various prohibited things. He ate at discretion, however, of the flesh of the victims which it was his duty to offer in sacrifice to Trophonius primarily, and then to his children; next, to Apollo; to Jupiter; to King Saturn; to Juno Hemiocha; as well as to Ceres, surnamed Europa, who was said to have been the nurse of Trophonius. An augur inspected the entrails of the victims, and predicted whether Trophonius would receive his worshipper with favour. The night preceding the descent into the sacred grotto, a ram was sacrificed in the ditch of Agamedes, and the neophyte was afterwards conducted to the river Hercyna. Having been duly washed and purified by two youths, he was then led by the priests to drink of the water of the two fountains of Lethe, or Oblivion, and Mnemosyne, or Memory; that, on the one hand, he might forget all his past, and, on the other, recollect unerringly whatever he might see or hear in the cave of Trophonius. Then he was admitted to offer up his homage to a statue, the work, it was said, of Dædalus, which the priests revealed only to intending suppliants. After which, the purified neophyte, clothed in a linen tunic, and wearing a peculiar kind of sandals, repaired to the oracle.

The oracle, situated on the hill which overhung the

sacred grove, was enclosed by a circular platform of white marble, with an iron grating, in which a certain number of gates was hung. Within the enclosure, an oven-shaped opening, constructed with much art and regularity, enabled the courageous explorer to glide into the cavern. There was no staircase to assist his descent; only a frail and narrow ladder, at the bottom of which he found, between the soil and the edifice, an exceedingly small hole, and into this he thrust his feet, while reclining his body on the earth, and holding in each hand a cake kneaded with honey. But no sooner had he made his way into the opening as far as his knees, than his body was carried forward with as much violence and rapidity as if it had been engulfed in one of those wild and powerful whirlpools occasionally formed by mighty rivers.

When the neophyte had penetrated into the secret cave, the future was not always revealed to him in the same manner: sometimes the coming events were shown to him as in a vision; sometimes he heard a solemn and terrible voice pronouncing the words of prophecy. As soon as the oracle ceased, he returned to the upper air. But he was compelled to ascend backwards; that is, with his feet foremost.

Then the priests immediately seized upon the visitor, and after seating him on what was called the Throne of Mnemosyne, situated at a short distance from the secret cave, they inquired of him what he had seen and heard; after which they restored him to his friends, who carried him away, bewildered and distraught, and almost incapable of recognition either by himself or by others,

into the temple of the Good Genius and Good Fortune.

And Pausanias adds these words, which are not exactly reassuring: "He recovered, however, after awhile, both his reason and his *faculty of laughing*."

After all, these ceremonies would seem to have been more frightful than really dangerous, since Pausanias asserts that of the thousands who descended into the grotto no one died, except a certain soldier of the household guard of Demetrius, who had the imprudence to venture into the *penetralia* without observing any of the usual initiatory rites; and whose intention, moreover, was less to consult the oracle than to carry off the gold and silver which he supposed to be hidden in the cave.

At all events, the oracle was held in great renown in Greece; and it is related that in the wars of Messenia, the valiant Aristomenes, having lost his buckler while too ardently pursuing the flying Spartans, descended into the cave of Trophonius, in obedience to the orders of the Delphian Pythoness, and there recovered the missing shield, which, at a later date, he consecrated at Lebadeia in token of his gratitude.

It would appear that the oracle did not cease to work its wonders long after the extinction of all the prophetic voices of Greece.

Though human enlightenment, says M. de Pouqueville, had made some progress, the sacred grove and cave of Trophonius continued to afford a basis for numerous theories up to the close of the second Christian century.

Lucian, who lived, it is supposed, in the reigns of the

two Antonines and Commodus—that is, from about 120 to 200 A.D.—has bestowed some excellent raillery, with his usual admixture of sound shrewd sense, on the hero and his oracle, in one of his celebrated *Dialogues*.

He represents Trophonius as extolling his oracle to Menippus in the following terms :—

“As for myself, I am a hero, and I make known what will be to all who descend into my sacred cavern. Thou hast never been at Lebadeia, or thou wouldst not doubt me.”

Menippus replies :—

“What dost thou say? What? Is it necessary to have been at Lebadeia for me to feel sure that thou art dead here, as we all are, and to discover that thy charlatanry is thy sole distinction? Is it first necessary that one should be covered with a mysterious veil, should carry ridiculously a cake in one’s hands, and, thus pleasantly equipped, should descend into the depths of thy cave, through a small, dark, and narrow hole? I prithee tell me, in the name of thy divine art, what it is to be a hero; for, in truth, I am unable to discover.”

Trophonius. A hero is a being who partakes of the nature both of the gods and of man.

Menippus. In other words, who is neither exactly god nor man, but both at once! In that case, where is thy divine half now?

Trophonius. Delivering oracles in Bœotia.

Menippus. I understand nothing of all these *oracular* distinctions; but of one thing I am very sure, that I see here *the whole* of Trophonius among the dead.*

* Lucian, *Dialogue* iii.

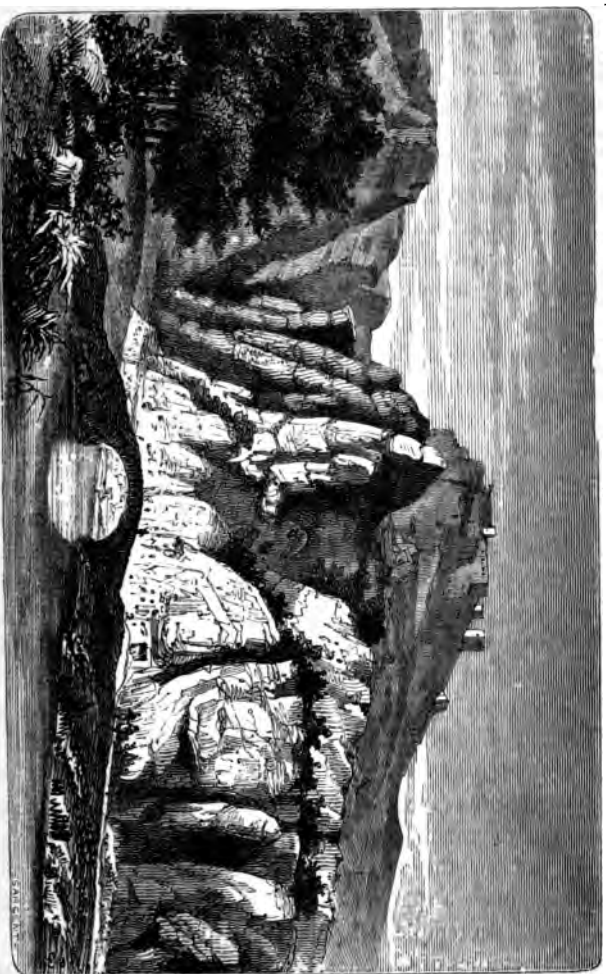
Lucian's good sense was in advance of the good sense of the public, who, however, soon became aware of the folly of these absurd superstitions. And yet who will venture to affirm, without fear of contradiction, that in some of our provinces, those which are least favoured in regard to educational advantages, the credulity of the vulgar does not too frequently "incline the ear" to predictions not less futile or ridiculous than those of ancient Greece?

The limestone mountain in which this cavern is situated is almost honeycombed with grottoes, so that the traveller finds it difficult to identify the one associated with the half-forgotten demigod.

The modern town of *Livadhia* (Lebadeia) is situated on two opposite hills, rising on each bank of a small stream, called *Hercyna* by Pausanias; but the greater part of the houses are on the western slope, on the summit of which is a ruined castle. Pausanias says that the *Hercyna* rose in a cavern from two fountains close to one another,—the two fountains already described as entitled respectively the Fountain of Oblivion and the Fountain of Memory. Now, in reality, the *Hercyna* is but a continuation of an occasional torrent from Mount *Helicon*. But at the southern extremity of the town, on the eastern side of the castle-hill, are some copious sources, which we cannot doubt to have been the reputed fountains of the *Hercyna*.*

The fountains on the right bank are warm, and are called *Chilia* (ἡ Χιλιά), and sometimes τὰ γλυφὰ νερά (or,

* Dodwell, "Tour through Greece," i. 216, *et. seq.*



THE CAVE OF TROPHONIUS.

the water unfit for drinking); those on the left bank, which are cold and clear, bear the name of ἡ Κρύα, *Krya* (or, the cold spring). Dr. Smith observes, very justly, that neither of these two sets of fountains rise out of a cave, and, consequently, they do not entirely answer to the description given by Pausanias; but a cavern lies close to each, and in the course of time, since the demolition of the sacred buildings of Trophonius, the caverns may easily have been choked up, and the springs have issued in different localities.

The question, however, arises, Which of the caverns contained the supposed sources of the Hercyna?

The answer depends upon the position we assign to the sacred grove of Trophonius, in which the source of the Hercyna was placed. Leake thinks it lay on the right or eastern bank; Ulrichs, on the left or western. The latter conjecture appears more probable on a strict interpretation of the language used by Pausanias; and in that case, the ancient city would have occupied the eastern bank, and the grove of Trophonius would have flourished on the western.

The most remarkable object in the grove was the Temple of the hero, containing his statue by Praxiteles; a temple of Demeter, surnamed Europe; a statue of Zeus Hyetius (Pluvius) in the open air; and higher up, on the mountain, the oracle (τὸ μαντεῖον). Ascending still further, the visitor came to the hunting-place of Persephone; a spacious but unfinished temple of Zeus Basileios; a temple of Apollo; and another temple, containing statues of Chronos, Zeus, and Hera. As we have seen, there was also a chapel of the Good Dæmon and

Of Good Fortune, in which the neophyte intending to Consult the oracle first passed a certain number of days. This has been identified with a square chamber, cut out of the rock, near the fountain of Krya.

The cavern usually regarded as the entrance to the Oracle is twenty-five feet in depth, and terminates in a hollow filled with water.

THE GROTTO OF THE CUMEAN SYBIL.

Cuma, the ancient *Cumæ*, lies on the Campanian coast, about six miles south of the Cape di Misene. It was one of the most ancient as well as one of the most famous of the Greek settlements in Italy, and retained its celebrity down to the fifth century before Christ, when it was captured and ruined by the Samnites. Its principal legendary association is with the famous Sibyl, who, according to almost all the traditions of antiquity, resided there; though, as Mr. Bunbury points out, there can be little doubt that the myths connected with her were brought by the Greeks from Cyme in Asia Minor, and transferred from Gergis or Gergithes in the Troad to the Italian Cumæ.

The Cave of the Sybil was still supposed to exist in the historical period; and a vast subterranean chamber or grotto, so called, hewn out of the eastern side of the citadel-rock, was pointed out in the time of Virgil:—

“Excisum Euboicæ latus ingens rupis in antrum.”

It was visited by Justin Martyr. “Being at Cumæ,” he says, “we saw a large basilica dug out of the rock, where they said the Sibyl had pronounced her oracles.

It had in the middle three large basins, also hollowed out of the rock, which had served for the lustrations of the Sibyl, who afterwards retired into the innermost part of the basilica (*ἐνδότερον τῆς βασιλικῆς οἴκον*), and there delivered her predictions of futurity from an elevated throne."

Virgil represents the first interview of Æneas with the Sibyl Deiphobe as taking place at Cumæ :—

" Up to the height Æneas hies
 Where Phœbus holds his seat,
 And seeks the cave of wondrous size,
 The Sibyl's dread retreat,
 The Sibyl, whom the Delian seer
 Inspires to see the future clear,
 And fills with frenzy's heat ;
 The grove they enter, and behold
 Above their heads the roof of gold . . .
 Within the mountain's hollow side
 A cavern stretches high and wide :
 A hundred entries thither lead ;
 A hundred voices thence proceed,
 Each uttering forth the Sibyl's rede.
 The sacred threshold now they trod :
 ' Pray for an answer ! Pray ! The god,'
 She cries, ' the god is nigh !'
 And as before the doors in view
 She stands, her visage pales its hue,
 Her locks dishevelled fly,
 Her breath comes thick, her wild heart glows,
 Dilating as the madness grows,
 Her form looks larger to the eye,
 Unearthly peals her deep-toned cry,
 As breathing nearer and more near
 The god comes rushing on his seer."

They still show at Cuma the grotto where the famous Sibyl imposed upon the dupes who resorted to her for advice. Carpentier describes it as neither remarkable for its dimensions nor for natural embellishments. The bottom is occupied by a kind of basin, resembling the crater of an ancient volcano, which incessant percolations

keep constantly half-filled with water. Hence, the visitor is compelled to mount on the shoulders of his guide to reach the narrow opening or crevasse where the Sibyl formulated, it is said, the decrees of Fate to profane ears; this prophetic *soupirail* is surrounded by several natural benches, evidently modified in shape by human handiwork, and so arranged as to serve for a place of rest or repose for the goddess of the place and her attendants. There is also shown, in the upper part of the cavern, a separate and private entrance, reserved, it is said, for illustrious and influential personages, when they had occasion to seek the Sibyl's advice.

Many memorials of antiquity, of the highest interest, are to be found in the neighbourhood of Cuma.

THE BLUE GROTTO.

In the romantic island of Capri, the ancient *Capræ*, historically celebrated from its associations with Tiberius, there are many natural wonders which cannot fail to move the admiration of the traveller, but none more unique in beauty than the *Grotta Azzurra*, or Blue Grotto. This renowned grotto is an enormous natural cavity, assuming the form of an elliptic vault or dome, one hundred and sixty feet in its major, and one hundred and twenty in its minor diameter, and seventy feet high. It occurs in the solid rock, which rises precipitously from the sea. The entrance is so narrow that admission into the interior can be obtained only in fair weather, and when the sea is calm. It is related that not a few travellers, surprised while within the cavern by a sudden storm, which effectually closes up the entrance,



have been compelled to remain for several days in a very awkward and even dangerous captivity.

The Blue Grotto owes its name to an optical phenomenon which enriches the walls with a soft, luminous, and delicate azure colouring. This phenomenon is due to the horizontal refraction of the light on the sea-waters, which act like a glass, and tint with their own hues the rays which they transmit. "The waters of this placid subterranean lake," says a recent traveller, "are the brightest, loveliest blue that can be imagined. They are as transparent as plate glass, and their colouring would shame the richest sky that ever bent over Italy. No tint could be more ravishing, no lustre more superb. Throw a stone into the water, and the myriad of tiny bubbles that are created flash out a brilliant glare, like blue theatrical fires. Dip an oar, and its blade turns to a splendid frosted silver, tinted with blue. Let a man jump in, and instantly he is cased in an armour more gorgeous than ever kingly crusader wore."

A graphic description of this celebrated grotto is given by Alexander Dumas :—

"Figure to yourself an immense cavern, wholly of azure, just as if Providence had been pleased to make a tent out of some superfluous shreds of firmament ! A water so limpid, so transparent, so pure, that in navigating it one seems floating upon condensed air ; above, pendent stalactites, like reverted pyramids ; beneath, a golden sand, mingled with submarine vegetation ; while along the sides, which are washed by the waves, fantastic growths of coral put forth their dazzling branches."

The great composer, Felix Mendelssohn, has furnished

in his delightful "Letters," a picture as interesting as is accurate of the Blue Grotto :—

"The sunlight," he says, "broken and deadened by the green sea-water, produces the most marvellous effects. The huge rocks are entirely lit up by a kind of greenish and sky-blue radiance, which gives one almost the impression of moonlight ; yet one can distinguish very clearly every angle and fissure. As for the sea, it is everywhere penetrated by the rays of the sun, so that the black bark glides on a clear and brilliant surface ; the water is the most dazzling blue I ever saw, without any shade or obscurity ; it forms, as it were, a disc of the most translucent crystal ; and as the sun traverses the liquid mass, one can see with perfect distinctness everything transpiring beneath the surface, and the sea reveals itself with all its inhabitants. You perceive the corallines and the polypes attached to the rocks, and, at a great depth, fishes of all species, which dart to and fro, and cross one another in every direction. The rocks appear more and more sombre as they lie nearer the water, and at the point where they touch it they seem quite black ; but you can still see beneath them the shining water, in which crustaceans and fish and worms are disporting themselves ; each stroke of the oar awakens in the grotto the most astonishing echoes, and as you pass along its sides you discover a succession of phantasmagoric scenes. The whole effect is magical. If you turn round towards the mouth of the grotto, the daylight which traverses it appears of a yellowish red, but it does not penetrate further than two or three paces, so that you are there quite alone upon the sea, with rocks above, and a sun of your

Own ; you feel as if you could accustom yourself, so to speak, to live under water."

It is believed that the ancients were not acquainted with the Blue Grotto, for no reference to it occurs in their writings. If it was ever known, at all events it had passed utterly into oblivion when, in 1826, two adventurous Englishmen, bathing on the sea-shore, conceived the idea of making their way through the opening in the rock, and discovered this natural curiosity, which now enriches the fishermen of Capri.

GROTTO OF ST. ROSALIA.

The Grotto of St. Rosalia, the illustrious patroness of Palermo, is excavated in a mountain of moderate elevation, which rears its bulk on one side of the roadstead of Palermo.

This mountain, now known as *Monte Pellegrino*, formerly bore the name of Mons Ereta ; it served as the site of an impregnable encampment in which, for five years, Hamilcar defied the efforts of the Romans. Monte Pellegrino, after being completely neglected and deserted for a long period, suddenly became, in 1624, after a series of more than half-legendary events which we shall briefly record, the object of the veneration of the Sicilians, and the goal of thousands of devout pilgrims. At the expense of the State, a superb though somewhat steep road, the *Scala*, was constructed ; it rises in a succession of terraces, above precipices and escarpments, to the very threshold of the sacred grotto, which is situated close to the wind-swept summit of the mountain. Around the grotto was erected an enclosure of buildings,

forming a kind of court, where dwelt the monks and attendants dedicated to the worship of the holy patroness of Palermo : finally, opposite the grotto, at the other extremity of this court, of which the precipitous wall of the rock forms the bottom, a chapel was built, which the devotion of the pilgrims speedily enriched with numerous magnificent offerings.

From a little terrace situated within a short distance of this chapel, where, some time ago, a little hostelry was established for the use of pilgrims and travellers, the visitor enjoys one of the most splendid prospects imaginable : he perceives, just at the foot of the mountain, the elegant city of Palermo, and its suburbs, the *Bugaria* and *il Colee*, with their beautiful villas and their verdurous shades ; further away, he sees the winding ridge of some of the higher peaks of Etna, though separated from him by the entire length of the island ; finally, on the sea-coast, he discovers the Lipari Islands, gracefully outlined against the sky, and the ever-smoking cone of Stromboli.

But now let me attempt to explain the influx of visitors attracted by devotion and curiosity, or by both, to the grotto of St. Rosalia and the summit of Monte Pellegrino.

St. Rosalia, according to a popular legend, sprang from the family of Roger, grandson of the celebrated Tancred de Hauteville, and first king of Sicily, who flourished in the early part of the twelfth century. Another legend represents her to be the niece of King William the Good, who reigned over Sicily from 1150 to

1154, and was succeeded by his son, William the Bad: other chronicles, again, assert that she was simply the daughter of a Sicilian count, named Sinibald.

However this may be, at the age of sixteen St. Rosalia was endowed with a marvellous beauty, which had rendered her, scarcely less than her virtues and piety, the admiration of all Sicily, when she suddenly disappeared in the year 1159; as no traces of her could be discovered, popular superstition imagined that she had been carried up to heaven as a reward for her purity of life and character. The legend, however, accounts for the disappearance of the devout young maiden by relating that, seized with a deep weariness of the frivolousness, vice, and passions of the court, she voluntarily retired to the obscure grotto of the Monte Pellegrino, where she passed many years in solitude and prayer. When death, continues the legend, surprised the saint in the retreat she had chosen, the angels took upon themselves the task of interring her, and they deposited upon her sacred remains a quantity of roses, which they have never ceased to renew when faded.

Yet the beauty, the virtues, and the misfortunes of the saint had completely died out of the memory of the Sicilians, when, five centuries later (in 1624), Palermo became a prey to the horrible ravages of the plague; in vain, prostrate before the holy altars, did its inhabitants implore the compassion of Heaven. But it happened one day that a citizen, renowned for his piety, descended from Monte Pellegrino, announcing that he had had a celestial revelation, and that the bones of St. Rosalia rested unhonoured in a cave of that mountain; adding,

that if these sacred remains were carried thrice round the city, the pestilence would immediately cease. A deputation repaired to the mountain; the bones of a saint were discovered; and, on the following day, a procession bore them in great pomp three times round the walls, and the plague suddenly disappeared.

In grateful acknowledgment of so noteworthy service, the inhabitants of Palermo chose St. Rosalia as the patron-saint of their city. The sacred remains were enshrined in a magnificent silver reliquary, ornamented with precious stones and of precious workmanship, which was solemnly deposited in the ancient cathedral of the city.

Since that memorable day St. Rosalia has been for Palermo and all Sicily what San Gennaro has been for Naples. Her festival, which is celebrated in the month of July, lasts over five days, and excites an almost incredible enthusiasm. An image of the patron-saint promenaded through the main street of the city in the midst of an immense concourse of people, on a car whose crest seems as high as the sky-line of the loftiest mansions, while its interior is filled with musicians; and the gorgeous equipage is drawn by forty mules. This festival ceremony is accompanied by horse races and fairy-like illuminations.

A statue of St. Rosalia has been erected in the sacred grotto, near the extremity. She is represented as a beautiful young girl, with a pensive air of devotion, adoring the cross, towards which she raises her hands with closed eyes. So mysterious is this statue, and so un-

expectedly does it loom out of the obscurity, that, even within a few paces of it, the visitor thinks it is some young Sicilian absorbed in a religious ecstasy: a feeble light, thrown by numerous tiny lamps of silver, suspended at different points, encourages the illusion; the wavering rays seem to communicate their movement to the sacred effigy. The delicate expression of its features, breathing simplicity and resignation, its calm and gentle attitude, the sweetly floating lines of its garments, captivate and charm the sight long after one has discovered one's error. The head and hands have been wrought in beautiful Parian marble: the vestments are of gilded bronze, covered with jewels of great price.

The authors of the famous opera of "Roberto il Diavolo" have converted the grotto of St. Rosalia into a vast monastery founded by the saint; and it is thither Count Robert, guided by Bertram, repairs, in the midst of the shadows of nuns accursed, to seek

" Le rameau toujours vert, talisman redouté,
Qui donne la richesse et l'immortalité."

The famous talisman, the e'ergreen branch,
Which gifts with wealth and an immortal youth.

NUMEROUS GROTTOS KNOWN BY DESIGNATIONS BORROWED FROM RELIGIOUS TRADITIONS.

We find in many countries of Europe, and especially in France, a great number of caverns whose names recall and perpetuate the superstitious ideas of antiquity.

Frequently, for instance, we find them labelled with the names of "Grotto of the Fairies," the "Goblin's Cave," the "Dragon's Cave," the "Cave of the Pyxies."

Or we find them dedicated to some holy hermit who has made them his retreat at a more or less distant epoch, or has driven out of their recesses pretended dragons or demons—in other words, the pagan superstitions whose popular tradition is in this way preserved.

Caves have been the favourite asylums of men suffering for conscience' sake from the days of the Hermits of the Thebaid down to those of the Covenanters. In many parts of the Scottish Highlands the traveller's attention is drawn to the dark and dreary hollows, where the stern zealots of Calvinism secreted themselves from the pursuit of their enemies. In the early ages of Christianity, those who embraced the "new superstition" were continually compelled to seek protection from persecution in the solitudes of the mountains and the deserts. Others there were who, believing an ascetic life peculiarly acceptable to God, withdrew to these lonely wastes that they might the more surely avoid the snares and temptations of the world. At all events, the caves of Egypt and Asia Minor and Palestine could tell the most pathetic tales, had they but a voice, of saintly endurance and human suffering. Canon Kingsley remarks that, about the end of the fourth century after Christ, the mountains and deserts of Egypt, more particularly, were full of Christian men who had fled out of the dying world, in the hope of attaining everlasting life. Wonderful things were told of their courage, their abstinence, their miracles, and also of their heroic virtues, of their purity, their humility, their helpfulness, and charity to each other and to all. The legendary records of the saints and hermits open up to our curious gaze many interesting glimpses

of the life they led in the cavern and the grotto. Thus, we are told of St. Antony that he found a cavern in a mountain, thronged with creeping things on account of its age, which deserted it as soon as he took up his residence in it; and that there he stationed himself, with a supply of water, and loaves sufficient for six months' sustenance. Of Paul, the first hermit, we find it written, that flying into the desert hills, he reached a stony cliff, at the foot whereof was, nigh at hand, a great cave, its mouth closed with a stone. Having moved the stone away, he saw a great hall within, open to the sky above, but shaded by the spreading boughs of an ancient palm; and in it bubbled a clear spring, the rill from which, flowing a short space forth, was sucked up again by the same soil which had given it birth. There were besides in that cavernous mountain not a few dwellings, in which he saw rusty anvils and hammers. And it was here that Paul spent all his life in prayer and solitude, solemnly dedicating it to God. So we read of a remarkable hermit, named Great St. James, whose biography has been written by Theodoret of Cyra, that retiring to the peaks of the loftiest mountains, he passed his life upon them; in spring and summer haunting the woods, with the sky for a roof, but sheltering himself in winter in a cave.

In France the tourist cannot fail to notice how frequently the word *Balme* or *Baume* occurs as a designation for a cavern. It would seem to be of a venerable antiquity, and probably is of Celtic origin: we may refer to the caverns of the Grande Balme, Notre Dame de la Balme, Sainte-Balme, Sainte-Baume, Baume-les-Dames,

Baume-les-Messieurs, and the like. This denomination is chiefly met with in the south and east of France, in Languedoc, Provence, Dauphiny, Franche-Comté, Burgundy, Limousin, Poitou, the Bèverais, and Anjou ; it is also very common in Switzerland. The use made of the word *Balma* in the *Acta Sanctorum*, written before the eleventh century, and also by the chronicler Joinville, is a proof of its ancient origin.

CAVERNS WHICH SERVED AS SUBTERRANEAN HABITATIONS
OR PLACES OF REFUGE IN TIME OF WAR.

Modern history records numerous examples of caverns being made use of as temporary or even permanent



CHURCH OF REMONAT.

dwelling-places. The custom, according to a French writer, has lingered down to our own day in many parts of France, where whole villages, as at Remonat, in Franche-Comté, have been excavated in the anfractuosités of the soil. Some of these grottoes afforded a refuge to the neighbouring population during the civil

wars of France, and particularly during those of the League.

It was stated quite recently, in an Italian newspaper, that there existed at Naples, at the foot of the hill of San Martino, some obscure caves, or "antres," as the poet calls them, inhabited by several hundreds of individuals. They were known as the Grottoes of Spagari. Some of them are excavated under the cliffs of Brancaccio: the traveller descends into them through a narrow opening which admits just light enough to illuminate the caverns for a few feet around; the rest is always in darkness. Their inhabitants he will find engaged in the manufacture of rope; they all live "beneath the surface," huddled close together, and with no separation between families. A few enjoy the luxury of a small mattress; others rest on a handful of straw, with a tattered coverlet. The same newspaper stated, however, that the Government were adopting measures to improve the condition of these unfortunate troglodytes.

There is not a province in France, as might be expected in a country so often devastated by civil and foreign war, where you cannot find examples of similar caverns; and very frequently the French journals announce the accidental discovery of hitherto unknown subterranean retreats. The following interesting narrative is of recent date:—

"In a field of the commune of Saint-Sulpice-le-Donseil, a peasant saw one of his cattle sink into a hole. It occurred to him to explore the chasm; and great was his surprise to find that it opened into a subterranean grotto. He quickly spread abroad the

news of his discovery, and everybody hastened to visit the cavern, whose existence was unknown even to the oldest inhabitant. Its plan was laid down by the mining engineers of the Creuse, and was found to present some curious details of arrangement, such as we do not meet with in the numerous monuments of this kind bequeathed to us by the generations of the past. The grotto, which is excavated in a gray granite of no special solidity, is in an excellent state of preservation: evidently it is the work of human industry; this is shown by its peculiar form, and by unmistakable traces of tool in certain parts. After traversing the entrance, the visitor with difficulty makes his way into an inclined gallery about forty feet in length, and nearly twenty below the surface; this section is in the worst condition. Next he arrives at a circular gallery, about seventy-five feet in circumference, in whose centre rises a huge pillar not less than eighteen feet in diameter; the peculiarity of this gallery is that its sides, which are hewn granite, are not vertical, but curved like an egg. At eighteen feet to the left of the inclined gallery, and at an elevation of two feet and a half above the level of the circular gallery occurs a small opening, through which a man can just contrive to squeeze himself; it gives access to a kind of corridor, about thirty-two feet long, at whose end is found a much larger and loftier apartment, which does not appear to have been completed. Air was admitted into the different galleries through three shafts, each about five inches in diameter, which formerly communicated with the exterior, but have been partly filled up by successive landslips."



It would be easy to multiply examples of grottoes and caverns of this kind, for, as we have said, they abound in France. We must be content, however, with naming a few of the most interesting. In England they are rare; partly owing to the configuration of the soil, and partly to the immunity which our island has long enjoyed from foreign invasion. Celtic pit-villages, however, have been discovered in the Isle of Wight; and the Yorkshire caverns have, at different times, afforded an asylum to the poor, the suspected, or the oppressed. Some of them are associated with the name of the popular English outlaw, Robin Hood.

The principal caverns of France are :—

In the crater of Mont-Brul, near Saint-Jean-le-Noir, in the volcanic chain of the Couërons.

At La Chaud de Perrier, to the west of Issoire, and on the banks of the Crouse. Here the caverns have been excavated in a volcanic terreous tufa, and used as habitations; not a few of them consisting of seven stories.

At La Chaud de Corant, on the road from Vic to Clermont, below the Martres de Vaires. They occur in a volcanic mountain, whose summit is crowned by a magnificent basaltic colonnade, upwards of seventy feet in height.

At Cournador and at Laval: wrought in a mountain of spongy and terreous tufa, which is also surmounted by columns of basalt.

At Crozon, in the department of La Finistère. These, nowadays, are inhabited only by clouds of ocean-birds, such as guillemots, and cormorants, and gulls.

At the village of Cangoireau, near Bordeaux, where they are still inhabited in part by the peasantry.

At St. Chamas, where the inland sea known as the Etang de Berre is divided into two basins by a narrow ridge, honeycombed with caverns, some of which are inhabited.

At Mont-Richard, in the department of Loir-et-Cher, the caverns present the appearance of a subterranean town; and their origin dates back, it is said, to the most distant epoch.

At the sources of the Ourcq, in the department of the Aisne, where, according to an old tradition, they formed the dwelling-places of the aboriginal inhabitants of the country.

At Rolleboise, on the left bank of the Seine; they are excavated in a mountain of solid chalk, traversed by numerous horizontal layers of flint.

At the Cave à Margot, at Sauges, near Saint-Pierre-d'Erve, in the department of the Sarthe.

At Savonnières, situated on the road from Tours to Chinon.

At Rencogne and at Bandia, both situated near La Rochefoucauld.

At Miremont or at Granville, lying between Sartat and Perigueux.

The *Grottes Demoiselles* (*las Doumaisellas*), in the rock of Taurach, beyond the village of Ganges, near St. Beauzile; these are famous for their stalactite incrustations.

Those of Loizia and Vados, in the Jura, are traditionally celebrated as the retreat of numerous hermits.

Crossing from France into Italy, we meet with a terrible example of a cavern serving as the theatre of an event of the most dramatic and odious character.

THE GROTTO OF LONGARA.

The Grotto of Longara, in Piedmont, is an unique hall or saloon, the vaulted roof of which is of moderate elevation, but whose area is immense: it measures upwards of one thousand two hundred feet in length, and in breadth varies from three hundred to nine feet, which is that of its solitary entrance,—this entrance, moreover, being obstructed by an enormous rock, which allows but one person to pass at a time. There is nothing specially remarkable in this excavation; but it will for ever call forth the horror of all honourable hearts, of all generous souls, from its association with an atrocious crime, which, in the space of a few minutes, made more than two thousand victims.

In 1510 the French army of invasion was driven back to the frontier after a murderous campaign: the rear-guard, commanded by the Chevalier Bayard, being checked at Longara, a certain number of those adventurers, who then formed the main element of all Continental armies, profiting by the disorder inseparable from a tumultuous retreat, spread themselves over the country, which they pillaged frightfully. The principal inhabitants collected the peasants, about two thousand in number, and persuaded them to take refuge with their families and an abundant supply of provisions in the cavern we have described.

But the adventurers having compelled some country-

men to make known the place of their retreat, hastened after them, thirsting for plunder. The unfortunate fugitives vainly attempted to move these murderers to pity, and to ask pardon for their wives and children. Reduced to despair, they barricaded themselves as best they could, and, favoured by the natural strength of the grotto, drove back the first who attacked them. The plunderers returned to the assault in increased numbers, but were unable to force an entrance into the cavern. Exasperated by their defeat, they conceived the abominable design of destroying, as they could not conquer, the unfortunate peasants; they collected a quantity of hay, straw, and fagots of green wood in front of the cavern, and set it on fire. The smoke rolled in immense clouds into the unventilated cavern, and in a few minutes its two thousand inmates, most of whom were women, children, and old men, perished in horrible agonies.*

Bayard, indignant at this sanguinary crime, hunted down the fierce but cowardly adventurers who had committed it, and caused the two guiltiest to be hung opposite the entrance to the cave. It is related that, while the wretches were in the hands of the executioner, a spectre, wofully lean and skeleton-like, not pale and wan, but embrowned by the deadly smoke, and throwing terrified glances all around, dragged himself out of the cavern; he was a youth of fourteen years of age, and the only human being who had survived the catastrophe. Bayard administered to him all the assistance his condition needed, and could not restrain his tears while listening to the pathetic story of the death of his companions.

* Some of the caves of Algeria could tell very similar tales of French barbarity.

My pen refuses to retrace its horrors, though they are preserved in the relations of contemporary authors ; you may judge of them from a single incident. A few gentlemen, at the moment the smoke began to fill the cavern, desirous of dying a soldier's death, resolved on forcing their way through the adventurers, or perishing sword in hand ; but the peasants threw themselves upon them, and disarmed them. The approach of inevitable death had not soothed or subdued the old class-hatred, and these miserable creatures were murdered in the darkness, just as all, nobles and serfs, were on the point of being involved in a common destruction. "No," cried the peasants, "ye shall not escape : ye brought us here, and here ye shall die with us !"

"And you, my friend," said Bayard to the youth, "how is it you did not perish with the others ?"

"I had noticed," he replied, "a slight glimmer of day in a corner of the grotto, and more through instinct than reflection I placed my mouth to the fissure. I soon lost consciousness, but the breath of air which entered through the imperceptible chink prevented me from being suffocated. When I regained my senses, I remembered all that had happened, but I was alone ; it took me a long time to crawl out of the cave of death !"

"I will have the bodies of the victims," said Bayard, "interred in holy ground, and you shall see their murderers hung."

GROTTO OF CAMOENS, AT MACAO.

Among the caves and grottoes rendered famous by the memories of sages, poets, or warriors, we must name

the Grotto or Cave of Camoëns, situated at Macao, the Chinese coast.

The great author of the *Lusiad* led a life of extraordinary adventure. After having served in several campaigns, directed by the viceroy of the Portuguese colony in India against the merchant fleets of Arabia, Camoë



GROTTO OF CAMOËNS.

returned in October 1555 to Goa, where he found an incapable governor and a vicious administration. Incapable of concealing or disguising his opinions, he satirized the abuses which disgusted him in some verses entitled "Disparates na India" (*Vagaries in India*). For this offence he was banished to Macao. Here he spent four years—four years of happy usefulness—chiefly in the composition of his immortal epic. It was in 1

sequestered grotto, still pointed out to travellers, that he wrote his exquisite verses. Never did poet choose a more poetical scene for his labours.

THE SALT-MINES OF WIELICZKA.

The immense excavations which men have wrought beneath the surface, with the view of appropriating the inexhaustible treasures concealed in the earth's womb, are scarcely connected with our subject. However, the characteristic appearance of the salt-mines of Wieliczka, and the great number of seemingly natural caverns which they contain, and which give them a certain resemblance to "a subterranean palace of the *Thousand and One Nights*," induce us to attempt a succinct description.

Wieliczka (pronounced *Vielitchka*) is a small town of four thousand inhabitants, situated about five miles to the south-east of the ancient city of Cracow, at the foot of the Carpathian or Crapack mountains, in that part of Poland which, when its infamous spoliation took place, was allotted to Austria. Immense mines of salt have been worked there over an area of 3000 yards in length from north to south, and 1200 in breadth from east to west, with a depth of 310 yards. It is not known exactly at what epoch these mines were discovered, but they were already being worked in the early part of the twelfth century. A popular legend, recorded by Adam Streller, explains their discovery after a sufficiently original fashion :—

The Princess Cunegonde of Hungary, betrothed to Boleslaus the Chaste, King of Poland, refused to accept from her father any dowry in gold or silver ; but as, on

her way to Poland, she passed by the salt-mines of Hungary, she flung into them her nuptial ring. On her arrival at Cracovia, Cunegonde halted there, made her attendants conduct her to Wieliczka, and ordered the earth to be opened in her presence. Her commands were obeyed, and a salt-mine of incomparable richness was discovered ; in the first block of salt extracted was found the princess's ring.

At the present day these mines, which do not employ fewer than a thousand individuals, besides four hundred horses, are one of the great feeders of the Austrian revenue. A few years ago their production exceeded 962,000 cwt.

It has been calculated that to visit in detail the inter-



SALT-MINES OF WIELICZKA.

minable labyrinths of galleries, halls, magazines, which seem to multiply beneath the steps of the visitor, it would be necessary to spend four weeks beneath the surface, and walk eight hours daily. The 'total length of the entire series of gal-

leries has been computed at two hundred and fifty-five miles.

One of the curiosities of these immense excavations, which reflect on every side like crystal the radiance of the lamps and torches, is the Chapel of St. Antony, situated on the first stage : this chapel is hollowed in the

mine itself, and consists wholly of salt ; altar, statues, columns, chair, ornaments, all are of salt.

On the second stage is a lake of two hundred yards in length and two fathoms and a quarter in depth, formed by infiltrations. It is the custom for visitors to make an excursion on the lake in a little skiff kept for the purpose. The wavering gleam of the torches in the midst of thick shadows, the boat gliding swiftly over the waters, the repeated blows of the pickaxe, the reports of the charges of gunpowder, remind the traveller of the terrible pictures of the Lower World painted with so much force by Virgil and Dante.

The mines of Wieliczka have been several times the theatre of brilliant festivals, of which the most memorable took place on the occasion of the marriage of Queen Sophia, wife of Vladislas Jagellon, in 1624. Each time, moreover, that a sovereign or a member of the imperial family of Austria visits them, they are specially decorated and illuminated in the most gorgeous manner : mirrors, lustres, draperies are arranged in a vast and regular hall ; a circular gallery, supported by pillars of salt, is reserved for an orchestra, whose harmonies produce a marvellous effect under these resounding vaults. The spectacle is one, however, of which the liveliest fancy can hardly conceive an idea, and our fairy story-tellers have invented nothing to equal it in fantastic splendour.

FINGAL'S CAVE.

" Thanks for the lessons of this spot—fit school
For the presumptuous thoughts that would assign
Mechanic laws to agency divine ;
And, measuring heaven by earth, would overrule
Infinite Power. The pillared vestibule,

Expanding yet precise, the roof embowed,
Might seem designed to humble man, when proud
Of his best workmanship by plan and tool.
Down-bearing with his whole Atlantic weight
Of tide and tempest on the Structure's base,
And flashing to that Structure's topmost height,
Ocean has proved its strength, and of its grace
In calms is conscious, finding for his freight
Of softest music some responsive place."

WORDSWORTH.

In all volcanic countries caverns, more or less considerable in extent, abound.

Among these caverns some—and they are the most spacious and the most profound, and consequently the least known—have been created by the ejection of eruptive matter, either through craters or lateral ducts ; others are due to the hollows produced by the cooling and condensation of the lavas ; others seem to result from the constant expansion of gaseous substances or vapours exhaled from the craters, or from the subsidence and disorder caused by the igneous liquefaction of the rocks ; others again are to be ascribed to the voids left between the solid strata and the pulverulent soils ; while in those which occur in basaltic formations, the mode of cooling into prisms frequently curvilinear and concentric forms vaults or domes, which later degradations gradually enlarge, and more and more denude, and eventually transform into caverns.

Not the least celebrated of the caves and grottoes due to the congelation of fused rocks is Fingal's Cave, in the island of Staffa, one of the storm-vexed Hebrides.

The island of Staffa is an immense mass of lava and

basalt ; immense basaltic columns are reared around its shores, which are precipitous, and inaccessible except at one narrow point, and seem to rise suddenly from the bosom of the sea. It was visited for the first time in August 1772, by one of the companions of Captain Cook, Sir Joseph Banks. Since then it has become a favourite shrine of curious pilgrims and summer tourists. Its objects of interest are four in number, and all lie on its



ISLAND OF STAFFA.

eastern coast : namely, the *Scallop*, or *Clamshell Cave* ; the *Buachaille*, or *Herdsmen* ; the *Great Colonnade*, or *Causeway* ; and *Fingal's Cave*.

The *Scallop* or *Clamshell Cave* measures thirty feet in height and seventeen feet in width at the entrance, but it gradually contracts as it approaches its interior extremity. On one side runs a regular range of semi-curved columns, resembling in appearance the ribs of a ship ; on the

other they have more of a mural character, with a general likeness to the surface of a honeycomb.

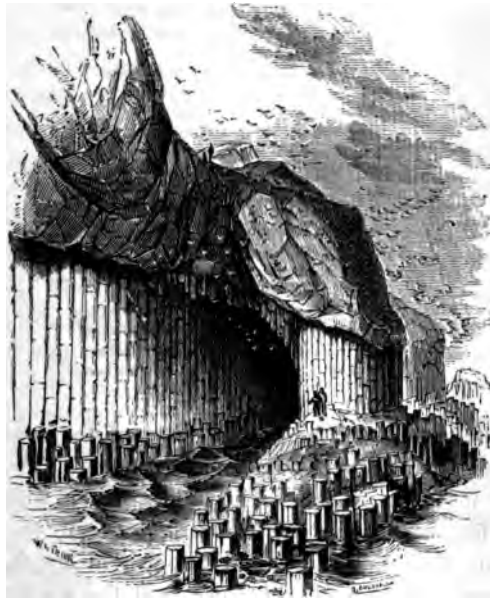
The *Buachaille*, or *Herdsmen*, is a conical islet, lying a few fathoms distant from the coast of Staffa, and about thirty feet in height. It rests on a foundation of curved horizontal columns, visible at low-water only, and consists of a mass of small but closely aggregated pillars, which seem to have been piled by the hand of a giant against the central nucleus, like lances against a military trophy. The general outline is remarkable for symmetry and grace.

On the island-shore, a short distance beyond the Herdsman, rises the stately pillared front of the *Great Colonnade*, with an average elevation of thirty-six feet, but decreasing in some places to three, and in others attaining to even fifty-six feet. The columns are about two feet in diameter, and of various shapes; trigonal, quadrilateral, pentagonal, and hexagonal; but all are set together in admirable order. At the base of this wonderful colonnade, and inclining from it towards the sea, runs the Great Causeway; a basalt platform, composed of the tops of extensive series of solid pillars, which, in the course of ages, have been raised to a level with the storm-driven waters of the Atlantic.

Fingal's Cave opens immediately beyond a rounded cliff, at the termination of the Great Colonnade and Causeway. The entrance is worthy of a palace which might have been erected for the Ocean-God of Greek mythology. It consists of huge columnar ranges, spanned by a magnificent decorated arch: the sides are formed of lofty pillars; the floor is the tranquil sapphire of

the sea ; and the general aspect is that of a colossal Cathedral, into whose nave the waters have found their way, filling every echo with solemn mysterious harmonies.

Dimensions :—228 feet, in length, from the east high-water point to the head ; 212 feet, in length, from the commencement of the arch to the head ; 33 feet, width,



FINGAL'S CAVE.

at the entrance ; 59 feet, height, from high-water to the point of the arch ; depth of water, 25 feet at the entrance, and generally about 24 feet to the head.

Sir Walter Scott has described this magnificent cave ⁱⁿ his vigorous and lively verse :—

" The shores of Mull on the eastward lay
And Ulva dark, and Colonsay,
And all the group of islets gay
That guard famed Staffa round :
There, all unknown, its columns rose,
Where dark and undisturbed repose
The cormorant had found,
And the shy seal had quiet home,
And weltered in that wondrous dome,
Where, as to shame the temples decked
By skill of earthly architect,
Nature herself, it seemed, would raise
A minster to her Maker's praise !
Not for a meaner use ascend
Her columns, or her arches bend ;
Nor of a theme less solemn tells
That mighty surge that ebbs and swells
And still, between each awful pause,
From the high vault an answer draws
In varied tone prolonged and high,
That mocks the organ's melody.
Nor doth its entrance front in vain
To old Iona's holy fane,
That Nature's voice might seem to say,
' Well hast thou done, frail child of clay !
Thy humble powers that stately shrine
Tasked high and hard—but witness mine !"

Other caves on the further parts of the coast also exhibit the basaltic columnar arrangement. The *Boat Cave* measures 16 feet in height, 12 feet in width, and 150 feet in length : the *Cormorant's Cave*, 50 feet in height, 48 feet in width, and 224 feet in length. The columnar effect at the entrance, and the stateliness of the interior, are such as to justify almost any warmth of description ; and the contrasts of light and shade could be realized only by the magic brush of a Turner.

• GROTTO OF THE CHEESES.

On the banks of the Rhine, between Trier and Cob-
 entz, and near the small town of Bertrich-Baden, may
 be seen a natural exca-
 vation in the heart of
 huge basaltic rocks,
 which is not less re-
 markable than that of
 Fingal, though not of
 such considerable di-
 mensions. The pillars
 which form the lateral
 walls of this grotto are
 composed of rounded
 parts, and hence they have been compared to piles of
 cheeses. This is the origin of the local name of the
 cavern, *Die Kaesegrotta*.



GROTTA OF THE CHEESES.

Some very similar excavations occur in the Vivarais
 and in Upper Auvergne, two districts abounding in ex-
 tinct volcanoes. They are to be found also in Iceland,
 as well as in the neighbourhood of Etna and Vesuvius,
 which are furrowed by immense crevasses, resulting from
 the double processes of congelation and dislocation.
 The soil in most of the islands of the Grecian Archi-
 pelago is nearly everywhere cavernous: that of the fra-
 grant islands of the Indian Ocean, and more particularly
 of the Moluccas, appears to be supported wholly by
 vaults and cavities: that of the Azores, of the Canaries,
 of the Cape Verde Islands, as, in general, the soil of
 almost all small islands, is hollow and cavernous at many

points, and for this reason,—these islands are simply the crests or upper peaks of mountains, in which very considerable landslips and depressions have taken place, either through volcanic or aqueous action, or through atmospheric influences. In the Peruvian Cordilleras, where volcanoes are numerous, a host, so to speak, of caverns may be noted ; just as in the volcano of the isle of Banda, and in Mount Ararat, which is an extinct volcano. On Mount Benieguazeval, in the kingdom of Fez, there is a remarkable volcanic cavern, which emits flame and smoke, and though of small extent, is famous throughout the country.

CAVE OF PETCHABURY.

Not far from the town of Petchabury, near Bangkok, on the Gulf of Siam, rises a lofty mountain ; from whose elevated summit the traveller's gaze ranges, in the one direction, over immense fertile plains, in the other, over an horizon bounded by the vaporous azure of sea and sky.

On quitting this huge natural watch-tower, we descend, says Mouret, the French naturalist, into the depths of a cavern, three miles distant, which is an extinct volcano, or a "crater of elevation." Here four or five gróttos occur, two of which are of a surprising breadth and depth, and of a singularly picturesque character ; if the reader could behold them in the transcript of a faithful artist, he would be apt to pronounce them the creations of a vivid imagination, and to deny that anything so beautiful existed in Nature. The rocks, held for a long time in a state of fusion, have, while cooling, assumed the curious

forms peculiar to scorix and basalts ; then, at a later date, the sea receding,—and all these mountains have risen from the depths of ocean,—and the moisture of the earth continuing to percolate, they have become tinted with colours so rich and so harmonious, and have adorned themselves with stalactites so graceful and imposing, their lofty, whitely-gleaming colonnades apparently sustaining the roofs and sides of these subterranean palace-chambers, that the visitor fancies himself transported into the centre of fairy scenes of indescribable magnificence and beauty.

A skilful architect has been employed to render these caverns more accessible to visitors. He has made the best possible use of all the advantages offered by Nature, without injuring in the slightest degree their picturesque aspect. Had the workmen touched the rocks ever so little, it must have disfigured them ; but the architect has contented himself simply with levelling the soil, and constructing some magnificent flights of steps to assist the descent into the interior of the grottoes, and reveal them in all their splendour.

The larger and more romantic of the two principal caverns has been converted into a temple ; it is lined throughout its whole extent with a row of idols, the greatest of which is covered with gilding, and represents Buddha asleep.

GROTTO OF MONSUMMANO.

From Siam the seven-league boots of writer and reader transport us back to Europe and to Italy.

In the environs of the village of Monte-Catini, about

equidistant from Florence and Leghorn, is found a natural grotto, celebrated for its moist and wholesome exhalations, which are useful in the cure or relief of many disorders.

This grotto, whose discovery dates only from 1849, is described by Dr. Constantine James as an immense natural gallery, excavated in the solid heart of the mountain, whose name it bears, and communicating with the external world only by a narrow opening.

He who first penetrated into the interior must have thought himself in the midst of one of those enchanted palaces with which the imagination of the poets has peopled the isles of Paphos and Cytherea. All around and above are glittering vaults, delicate arabesques, stalactitic columns, marble seats, basins of the finest crystal; and, in the very centre of all these marvels, a sheet of water, warm and translucent, whose fragrant airs perfume the atmosphere. At every step the visitor, lost in wonder and admiration, expects to find himself confronted by some nymph or goddess, the *genius loci*. This subterranean palatial magnificence must surely exist, he says to himself, for the gratification of some supernatural Power! But instead of nymph or goddess, he meets only with rheumatic patients undergoing their course of vapour-baths.

GROTTO OF LA MADELEINE.

France, like Italy, has its *Grotta del Cane*; that is, a cavern exhaling a continual volume of vapour mortal or at least deleterious to any living creature which breathes of it.

It is situated about six or seven miles south of Mont-



pellier, at the foot of the hill surmounted by the Hermitage of St. Beauzile, between the route to Cette and the railway. Its opening, half-concealed by climbing plants, is very narrow; it is reached by a steep incline, consisting of rough large stones resting upon a bed of mud.

Language, we are told, cannot do justice to the beauty of this grotto, when the glare of lighted torches flings an uncertain radiance over its sombre roof, and the stalactites pendent from it: the dark, calm water,—for in this vast cavern sleeps a great subterranean lake fully three hundred and twenty feet in length,—on which glides the little skiff; the profound silence, broken only by the feeble cries of frightened bats startled from their usual hiding-places, produce a deep and lasting impression on the imagination. To the poet it may well be the entrance of the Pagan Hades, the Cocytus of Virgil; to the geologist, it is the Grotto of Adelberg, and the rivers and subterranean lakes of Carniola in miniature,—an example of those subterranean basins, those hidden reservoirs which feed the abundant springs of calcareous districts in general, and of the south of France in particular, as at Vaucluse, Malaucène, St. Clement, and Lez.

Every summer this grotto is filled, like the *Grotta del Cane* of Naples, with a great quantity of carbonic acid gas, and asphyxiating phenomena occur in the most dangerous manner for imprudent or ignorant visitors. In winter, on the contrary, you may penetrate without fear into the deepest recesses, and safely navigate the lake.

Now, whence comes the carbonic acid gas which is exhaled in this grotto?

The *Grotta del Cane* of Naples is, we know, in the

immediate vicinity of Vesuvius, and we also know that in the neighbourhood of volcanoes this gas issues, so to speak, from every pore of the earth ; but there is something very curious in this intermittent production occurring in the Jurassic limestone formation. Does the gas emerge from a fissure in the soil, or is it given off by the waters of the lake, which are slightly gaseous ? It is difficult to determine, for as water dissolves the carbonic acid gas, one can never tell whether the gas which it contains has been dissolved or disengaged by it ; and, during the production of the gas, the exploration of the cavern is impossible.

It has been remarked that volcanoes in full activity principally exhale hydrochloric acid ; that, as their activity diminishes, it is sulphuric acid which becomes predominant ; and, finally, that when they are extinct, carbonic acid is the only gas which escapes from their fissures. The evolution of carbonic acid from the Grotto of the Madeleine may, therefore, very well be the remains of the volcanic activity which, in its immediate vicinity, has elevated the basalts of Montferrier, and, more distant, those of Agde and St. Thibéry ; the last effects of that unknown force, of which the volcanoes of Auvergne, the Cantal, and the Vivarais are the grandest manifestation on the soil of France.

We shall now direct the attention of the reader to those grottoes and caverns which are the result of aqueous action.

MARINE GROTTOS AND CAVERNS;

That is, Grottoes and Caverns excavated by the Sea.

The sea, in breaking upon the shores, has wrought at numerous points certain profound excavations, the appearance of which is often singularly picturesque. Some of these excavations, which have been slowly fashioned, and, as it were, hammered out by the incessant action of the waves, present a truly fairy-like spectacle to the traveller.

"Hardly we breathe, although the air be free;
How massively doth awful Nature pile
The living rock, like some cathedral aisle,
Sacred to Science and the solemn Sea.
How that clear pool lies sleeping tranquilly,
And under its glassed waters seems to smile,
With many hues, a mimic grove the while
Of foliage submarine, shrub, flower, and tree.
Beautiful scene! and fitted to allure
The printless footsteps of some sea-born maid,
Who here, with her green tresses disarrayed,
'Mid the clear bath, unfearing and secure,
May sport at noontide in the caverned shade—
Cold as the shadow—as the waters pure." *

Among the most remarkable of such grottoes we may place those of Crozon.

CAVES OF CROZON.

These caves are situated on the coast of Brittany, in the Bay of Douarnenez; they are fifty in number, among which the most curious are, the *Birds' Cave*, the *Devil's Hole*, and the *Cave of Morgatte*.

The *Birds' Cave* is an excavation of about sixty feet in depth, which the receding tide leaves entirely dry. It

* Thomas Doubleday.

is entered through two natural arcades, fashioned out of **the** rock with admirable grace and boldness. The area **of** the grotto is sufficiently extensive to accommodate **at** least eighty persons.

The *Devil's Hole* is of a more fantastic character. Let **the** reader figure to himself a capacious furnace wrought **out** of the solid rock, beneath an overhanging promontory, **with** two arched entrances, which permit the visitor to **penetrate** into its interior, and in the centre of the upper **roof**, a long shaft or tunnel rising to the level of this same **promontory**. On entering by one of these arcaded ways, **the** visitor sees above his head this gap in the rock, shaped **like** a funnel, through which glitters a shred of azure sky ; **or** sometimes is thrust downwards the head of a curious **shepherd**, weary of watching his goats on the hillside. **The** wind engulfs itself in the shaft with a plaintive cry, **and** the ocean birds deposit there their nests.

As for the *Cave of Morgatte*, it is altogether prodigious **and** admirable. It can be entered only in a boat through **a** very narrow opening ; an opening so low that, at high-**water**, the boatman cannot stand upright ; but the cavern **itself** is of astonishing dimensions. At first the eyes, ac-**customed** to the light, can distinguish nothing in the semi-**obscurity** which prevails in the cave ; we hear only large drops of a yellowish water falling one by one into the **bark**, which glides along in silence, and the noise of the waves which, set in motion by the oar, break against the **base** of the rock with an ominous and singular sound.

But with all the impression produced by these curious

echoes, when the eye, accustomed to the obscurity, is able to distinguish objects, one cannot refrain from an exclamation of surprise and admiration at the spectacle which then presents itself.

The entire cavern seems irradiated with a thousand exquisite hues, and tapestried with fantastic coloured arabesques, of which no words at our command can convey any idea. The roof seems formed of long slabs of emerald-green marble, while along the sides the various tints of rose, and lilac, and pearly-gray blend into one another. At intervals, broad belts of an intense liquid red, fetid but brilliant, seem to ooze through the rock like drops of blood. The lower part of the wall, on either side, is diversified by large stones shining with rose and orange.

In the middle of the grotto rises an immense block of red granite, known as the Altar.

In the further end, a pebbly beach is found; and upon this beach another cavern opens, which is known to be immensely deep. The entrance, however, is extremely narrow, and no one has penetrated more than forty paces into the interior. Another and a similar opening occurs opposite the Altar, but the recess to which it gives admission is of inconsiderable extent.

The Cave of Morgatte is about one hundred and fifty feet deep, its height sixty feet, its average breadth seven feet. The name *Morgatte*, or *Morgana*, by which it is known, is apparently derived from two Celtic words, *mor* and *gan*; and if so, would seem to signify, "Born of the Sea." Some authorities assert that, during the era

Persecution, this grotto afforded an asylum to Christian believers, who celebrated here their sacred rites ; and that the rock which rises in the centre was thence designated the Altar. The inhabitants of the surrounding country tell, too, of a family who were once surprised by a storm while visiting the Morgatte, and who perished in its shades after some days of agony. The violence of the sea rendered the cavern inaccessible, and no relief could be conveyed to its unfortunate occupants.

The only tenants of the cavern nowadays are innumerable sea-birds, gulls, cormorants, guillemots, and the like.

Besides the grottoes of which we have spoken, fully fifty others, of varying dimensions, are to be found in the Bay of Douarnenez. All are excavated in the marble and in the granite, and present some noticeable details internally. One of them—namely, that at the Pointe de la Chèvre—is named in Breton *Queo Charivari* (the Cave of the Charivari), on account of the discordant cries of the birds which inhabit it.

GROTTOES OF ETRETAT.

We cannot attempt, within the narrow limits to which we are necessarily confined, anything like an enumeration of the remarkable caverns which break the coastline of Europe. A description of those of France and England alone would fill a volume.

The caves of Etretat are deserving of notice, however, on account of their picturesque magnificence.

They are three in number : the Trou à l'Homme (or Man's Hole), the Chambre aux Demoiselles (or Ladies'

Chamber), and the Trou à Romain (Romain's Hole): these form the principal curiosities of Etretat, in addition to the famous Needle, the Cauldron, the Porte d'Aval, the Manne Porte, the Petit Port, and the Vallease de Bénouville.

The *Trou à l'Homme* is an immense cavern, whose bottom is paved with white rocks, covered with fine sand. The visitor must beware of pushing his explorations of this cavern too far; it is of immense depth, and very dangerous. The *Trou à l'Homme* is situated beneath the *Chambre aux Demoiselles*, whose subterranean abode is established on the peaks which dominate the rock.

As for the *Trou à Romain*, it is a small grotto, excavated in the cliff, at an elevation of three hundred feet above the sea. Alphonse Karr, the Christopher Columbus—or rather, as he has designated himself, the American Vespuccio—of Etretat, relates the pathetic story of the unfortunate fisherman who has given his name to the grotto.

Romain Bisson, he says, the son of a fisherman Etretat, had been accustomed from his infancy to wander about the rocks, catching shell-fish, and collecting seaweed. When the conscription of 1813 was levied, Romain was pronounced fit for military service; but he repined at his lot, preferring to the military profession a life sown with many more perils than that of the battlefield and the bivouac. The wild life which he had led from his infancy, a gloomy physiognomy, and wayward

disposition, held him aloof, as it were, from his fellow-countrymen. The idea of quitting his beloved rocks became insupportable. Instead of joining his regiment, he concealed himself in a cave on the cliff, into which his parents lowered, every night, a supply of bread, water, and cider.

At the end of a twelvemonth, his retreat was discovered. When summoned to descend, he replied that he did not wish to become a soldier. He was warned that he would be arrested and shot, if he disobeyed: he would rather die, he answered, than become a soldier! His pursuers attempted to scale the cliff, but were compelled to renounce the idea. Then, after a fresh summons, they fired several volleys at him; to which he replied with stones and fragments of rock.

The siege lasted four days. At length, in want of water, his throat parched, his lips cracked, and worn with a burning fever, he resolved to husband his remaining strength for a final effort at escape.

He waited till the sea was at its highest, because the soldiers who watched him were then compelled to keep at a distance.

About ten o'clock the sea washed the foot of the rocks, and rendered approach impossible. Romain then descended, helping himself with both feet and hands, taking advantage of the smallest projection, and walking where none but birds had been before him. The soldiers discovered him, and fired shot after shot. On the following day, by dint of great precautions, they reached the cavern; but Romain was no longer there. They picked up on the beach his blouse and *sabots*; they

hurried in all directions to come upon his track ; but they could not trace him.

Two years later, the aspect of the world had changed. Napoleon was on his way to lonely St. Helena, and Louis "the Desired" had returned to Paris. Romain then reappeared ; for an amnesty having been declared, his life and liberty were safe. He found his paternal hut, but his mother was dead. He revisited his betrothed ; but she was married, and held in her arms a young and smiling babe.

Soon afterwards, Romain Bisson terminated his existence by throwing himself headlong from the summit of the cliff which had so long furnished him with an asylum. Was it love which led him to the commission of this fatal act ? That is a secret which Romain carried with him to his grave.

GROTTOES OF BONIFACIO.

Not the least remarkable of the remarkable excavations wrought by the incessant action of the waves are the Grottoes of Bonifacio, on the southern coast of the island of Corsica.

The town of Bonifacio occupies the summit of a steep, long, and narrow ridge of rock, which advances into the sea as if intent upon making a formidable demonstration, and then suddenly stops short. By continuously dashing against and beating upon the lower declivities of this ridge, which is composed of a grayish-white and easily disintegrated limestone, the sea has undermined the town to a considerable extent ; and though it has not yet succeeded in sweeping away the entire ridge, it has hollowed out a number of caverns and grottoes of astonishing

magnitude, whose mouth opens directly on the sea, and whose bottom is wholly covered by fresh and limpid waters.

One of these grottoes strikes through Mont Pertuisat, from side to side, just like a straight and regular gallery, wrought by the hand of man. Its two openings are very wide, and give free access to the light, which traverses the whole extent of this natural tunnel. The mountain is almost entirely insulated from the shore, and rises in the general form of a pyramid.

Beneath the citadel is found another cavern, at whose mouth the sea has accumulated such a heap of shingle that it is almost entirely closed, and the visitor can obtain access to the interior only by crawling along the sand and stones on his stomach. This cavern is longer than the other, but is less lofty, and, as the reader will suppose, is involved in complete darkness. It consists of a series of wide compartments, covered with incrustations and stalactites, and connected with one another by small, low, narrow corridors. As soon as you, the explorer, have passed the mass of pebbles which forms an embankment at the entrance, you find yourself once more on the brink of the water ; but it is a singular fact that, though the level of this water lies below the level of the sea, its taste is fresh, or, more correctly speaking, very slightly brackish : undoubtedly it proceeds from the infiltrations of the rain-waters which descend from the town and citadel, and thus it forms a natural cistern, which Bonifacio might advantageously utilize for sanitary purposes, as water is very scarce in the town.

"We penetrated," says a traveller, "into the interior

of this cavern, in a little skiff which we contrived to pilot there, though not without great difficulty, after we had cleared out the opening. The roof was tenanted by a few bats, which showed much alarm at the appearance of light in their dark, shadowy habitation ; the water was as clear as that of a fountain, and though, at several points, it was eight to ten feet deep, we could distinguish, with the help of our torches, the slightest irregularities of the rocky bottom. This subterranean gallery stretches diagonally under the citadel to a great distance. We followed it up until the mid-point of the cavern must have been above our heads ; then the vault declined almost to the water's level, and it was impossible to advance further. However, this was not the termination of the grotto, for the roof sank gradually, and not abruptly, like an enclosure, and the water—in other words, the gallery itself—was still seven to eight feet deep. It is possible that beyond this obstacle the roof may again rise, but it is quite certain that the grotto at its other extremity does not abut upon the sea ; for if so, it would necessarily open under water, and, as a consequence, the water it contains would be of the same level and of the same degree of saltness as that of the Mediterranean."

At the entrance to the harbour is another grotto, not of any great depth, but remarkable for the magnitude of its opening, which is upwards of one hundred feet in height : it is surmounted by the ruins of an ancient convent, and by the walls and batteries of the citadel.

The most remarkable cavern opens upon the sea,

at the mouth of the strait, with a grand arcade, pierced in a cliff which is as white and smooth as a wall. The water there is deep, and the waves dash into it freely. We come, at first, upon a grand corridor, which gradually penetrates into the inner darkness, and at length terminates abruptly against a wall of solid rock. Then we turn, on the left, into a lateral gallery, which conducts to the great hall or principal compartment : this passage is very difficult when the sea happens to be at all agitated.

When we entered this passage, says a traveller, there was a slight swell, and its influence was plainly discernible even in the heart of the cavern : the water, with its tranquil periodicity, struck the sides of the corridor and rolled up to the very roof, falling back again with a clamour of confused and resounding echoes. It was curious to see and feel the motion of our boat, which bounded lightly and gracefully under a vault like to that of the great cloisters of the Italian convents. Our boatman had wished to keep his mast standing, and the streamer touched the roof ; at length, in about the middle of the gallery, whether the roof was lower or the swell which tossed us higher, we experienced a sudden shock. The mast touched, and as we could no longer continue to rise with the water, the water began to rise upon us, and was visiting us in a very inconvenient fashion, when, to our great satisfaction, the unfortunate mast, which had hitherto stood firm, finally gave way. This was fortunate, for the boat would otherwise have foundered in a place where it would not have been easy to right her again ; and as for ourselves, we should assuredly have found it difficult to have made our way out of this hole, and more especially,

when in the open sea, to have summoned any boat to our assistance. A few vigorous strokes of the oar, however, extricated us from our embarrassment, and we glided gently and calmly into the most beautiful hall, I think, which Nature ever constructed : a basin, like that of a small lake, was filled with a water blue as heaven, and transparent as the air, flinging upwards, and in all directions, its azure reflections against each projection of an immense roof, all bristling with angles and ridges, and receiving the sunshine from a height of one hundred feet in the plain above, in the midst of myrtles and flowering laurels. The Greeks would have painted this retreat, in all its depth and mystery, as the palace of Thetis or Poseidon, and would have peopled its peristyle and corridors with the sacred forms of Nymphs and Tritons. Our fishermen, however, do not concern themselves with dreams and fancies so far removed from the reality of things. It must be owned, nevertheless, they were all struck with involuntary reverence in the presence of so much splendour and so much magnificence ; the architecture was that of a majestic temple, and a temple is always eloquent even when deprived of its divinities. A few seals, which the ancient navigators would not have failed to convert into Sirens, had chosen this rarely-visited cavern for their retreat : they frequently moved to and fro, in front of the entrance, like sentinels at their post, and took their rest in the interior on some slabs of rock, wave-worn in the course of ages. The *genius loci* is their protection ; and our seamen, though eager and incessant fishers, were content to survey them with pleasure, and to admire their gambols without any attempt at interrupting them.

GROTTO OF TORGHATTEN.

Norway, whose bold, rugged, and barren coasts are broken up and indented by the incessant attacks of the ocean waters, necessarily affords the physical geographer numerous examples of caves and grottoes wrought by their unresting action. As one of the most curious and imposing, we may attempt a description of that of Torghattan.

This grotto is a kind of gallery of astonishing regularity, excavated in an enormous rock, 500 feet in height, on an island of northern Norway: it measures upwards of 300 feet in length, while its breadth varies from 100 to 160 feet: its two entrances are situated 400 feet above the sea-level, and the one is 230 and the other 140 feet in circuit.



ROCK OF TORGHATTEN.

The flooring of this cavern is nearly horizontal, and is covered with fine sand; the lateral walls are polished, as if they had been wrought by the hand of man, over nearly their whole extent. Towards the centre of the grotto the roof is less elevated than at either end. Mariners relate that when the sun illuminates the interior and the surrounding landscape with its rays, the promontories, the picturesque rocky islets, the innumerable reefs, and the white-crested, glittering breakers, with their toss-

ing surf and clouds of spray, seen through the immense gallery as through a gigantic telescope, form a spectacle of incomparable beauty.

There is also found on the Norwegian coast a cavern not less remarkable for its extent than for the terrible meteorological phenomena of which it is the theatre. It occurs on a promontory of the Lyse-Fjord, the latter being an arm of the sea twenty-five miles long, and bounded on either hand by a precipitous rampart, of the gloomiest aspect, upwards of 1000 feet in height : it opens into the sea near the fifty-ninth parallel of latitude, at a short distance to the east of the port of Stavanger.

The cavern lies under a projection of the cliff, which overhangs it at an elevation of upwards of 2500 feet above the sea-level. To enter it the daring explorer must be lowered by a rope from the dizzy summit, availing himself as he may of the crags and ledges of the rock in his dangerous descent. It has been attempted by only a few adventurers ; and, moreover, the cavern presents nothing astonishing in itself apart from its magnitude. But it derives an adventitious interest from the singular meteor produced in its depths, when the south-east wind blows with violence, and eddies in furious gusts and broken gales on the immense fissure of the Lyse-Fjord.

At 2000 feet above the sea, and over two-thirds of the surface of the wall which rises southward of the mouth of the gulf, one beholds at intervals a lurid lightning flashing from the black rock, expanding at first, and then contracting, again to expand and to contract anew, and to diffuse itself in broken luminous shreds and fragments

before it can reach the northern rampart. The sheet of fire advances with a whirling, revolving motion ; and to this rotatory movement are due the apparent contractions and expansions of the lightning. Rapid detonations are heard, with ever-increasing force, before the flames issue from the rock ; a violent peal of thunder accompanies them, and reverberates in prolonged echoes through the narrow marine corridor, just as if a battery, concealed in the interior of the cliff, was cannonading some invisible redoubt on the opposite side.

Kraft records several other instances of caverns on the Norwegian coast in which the formation of thunder takes place. He dwells particularly on the Troldgjoel, or Mount of Prodigies, situated on the shore of the Joerend-Fjord, to the north of the sixty-second parallel, from whose sides, at every change of temperature, violent detonations, accompanied by flames and smoke, burst forth in prolonged cannonades.

Let us also mention, on the coasts of Norway, the grotto of the Maëlstrom, which is remarkable both for its extent and for the picturesque and manifold fissures worn in it by the incessant attacks of the sea.

CAVERN OF ST. MICHAEL, GIBRALTAR.

Islands and peninsulas, constantly assailed on every side by the billows of ocean, must necessarily furnish striking examples of caverns due to this disintegrating and irresistible action.

The peninsula of Gibraltar, at the threshold of the Mediterranean, presents us with St. Michael's Cave, the dimensions of which are considerable. Its myriad sta-

lactites add greatly to the picturesque effect of its marvelous natural decoration,—the work of the terrible and capricious element to which the existence of the grotto itself is due. Ford says that its interior is seen to the greatest advantage when illuminated with blue lights.

SCRATCHELL'S CAVE.

The Isle of Wight, as everybody knows, is separated from the mainland of Hampshire by a strait called the Solent, which varies in width from three-quarters of a mile to five miles. At its westward extremity there are numerous caverns of very considerable dimensions, tenanted by flocks of sea-birds. The most remarkable is the magnificent cavern, 150 feet high, situated at the entrance of Scratchell's Bay, and at the extremity of the celebrated and dangerous chain of rocks which mariners designate the *Needles*.

GROTTOES OF TOURANE.

From Europe we may now betake ourselves to Tourane, whose grottoes are excavated in the celebrated marble rocks which lie at the bottom of the Bay of Tourane, on the Cochin-Chinese coast.

These marble rocks are enormous grayish masses, fashioned into prismatic needles, and so precipitous that it is impossible to accomplish their ascent. Their gray and rugged surface is here and there diversified, especially on the westward face, by shrubs of the most brilliant green, lianas encrusted in the fissured stone, and a great number of euphorbias. The sand which surrounds their base is of the most dazzling whiteness,

and so fine that its shifting surface seems from afar like the continuation of that of the sea.

The Baron de Bougainville visited the marble rocks and the grottoes of Tourane in 1824, and in his published *Journal of the Voyage round the Globe of the Thetis and the Esperance* (1824-1826), gives the following description of them :—

The entrance to the principal grotto is excavated in the flank of the rock on the north-east, on the side facing the sea ; it is a low and gloomy opening. However, the visitor has scarcely advanced more than a hundred feet over a rugged, stony soil before he perceives daylight, and almost at the same moment he finds himself in a hall of lofty elevation, illuminated from above ; and then in a second, separated from the first only by a narrow passage : the latter presents a magnificent spectacle. Afterwards he enters another hall, which is still more impressive, and in which may be seen an enormous column attached to the roof, whose base is entirely separated from the soil. This chamber may be about eighty feet in height, and in a remote and obscure recess the visitor hears the sound of a waterfall. Infiltrations have occurred in many places, and fall in drops ; but stalactites are nowhere visible. Thousands of bats, furrowing the air in all directions, fill the echoes with their gloomy cries.

This cavern is not the only one excavated in the rocks. We may mention another, whose entrance is very dark, and partially concealed by the foliage of shrubs springing from the chinks and crevices of the rocks. This grotto contains a small pagoda ; some characters

traced on one of the sides of the altar make known to all whom it may concern that Messrs. Chaigneau and Vaunier, when on the point of quitting Cochín-China, visited this spot with their families in November 1824.

At a higher elevation is found another grotto, to which we ascend by a very narrow pathway. To the left of this grotto, which is very dark, and also contains an idol, a gloomy lateral passage unexpectedly opens upon a third, far more magnificent and imposing than those we have previously visited.



SUBTERRANEAN PAGODA OF TOURANE.

Figure to yourself, says M. de Bougainville, an immense rotunda, lighted from above, and terminated by an arched vault at least sixty feet in elevation, of marble columns of various colours, some of which seem to be cast in bronze, owing to the greenish incrustation laid upon them; the lianas traversing the roof and extending towards the soil, some in clusters, others in wreaths—as if to receive lustres; groups of stalactites suspended above our heads like enormous organ-pipes; altars, and

mutilated statues, and hideous monsters hewn in stone; finally, a complete pagoda, which, nevertheless, occupies but a very small part of this extensive area! Bring together now these objects in one and the same framework, and illuminate them with a confused light, and the reader will have an imperfect idea of the scene which presented itself to my gaze. You must pass under a portico, and descend thirty steps, to arrive at this enclosure. I felt myself profoundly moved, I confess, on setting foot in a place which the hand of the Eternal seems to have fashioned for his temple; everything, in fact, inclines to meditation and self-concentration; and it was, without doubt, similar excavations which furnished to the primitive Christians, who worshipped in the Roman Catacombs, the models of our sacred architecture, so powerful beyond all others in awakening religious sympathies. The deep silence which surrounded me, the absolute solitude, the sudden lowering of the temperature which affected me even to shuddering,—everything at first combined to produce an indescribable effect upon me, whose recollection is not even yet completely effaced from my memory.

*GROTTOES AND CAVERNS PRODUCED BY
SUBTERRANEAN CURRENTS.*

THE DEVIL'S HOLE, DERBYSHIRE.

It is said that the total length of the great caverns of Castleton, in the Peak district of Derbyshire, exceeds one thousand yards. They present a striking succession of cavities and defiles, of bottomless abysses, of subterranean



THE DEVIL'S HOLE, DERBYSHIRE.

lakes, and of massive columns, composed of brilliant stalactites, which support the gloomy vaulted roof; in a word, they combine all the marvels of the subterranean world.

Who has not heard of Eldon Hole, a deep, yawning chasm opened in the solid limestone rock? In the reign of Elizabeth, the Earl of Leicester is said to have bribed a man to descend into it for the purpose of ascertaining its extent and configuration. He was lowered a distance of seven hundred feet, and for awhile remained suspended in the abyss; then he was drawn up to the surface, but in a frenzied condition, and, never recovering his senses, he died eight days afterwards. To this incident Cotton alludes in some quaint verses:—

“Once a mercenary fool, ’tis said, exposed
His life for gold, to find what lies inclosed
In this obscure vacuity, and tell
Of stranger sights than Theseus saw in hell.
But the poor wretch paid for his thirst of gain;
For being craned up with a distempered brain,
A faltering tongue, and a wild, staring look,
He lived eight days, and then the world forsook.”

In reality, however, Eldon Hole is not more than 200 feet in depth, 20 feet in width, and 60 feet in length. In the “Philosophical Transactions for 1781,” the descent is recorded of a Mr. Lloyd, who was let down with a rope by eight men, and found the light at the bottom of sufficient clearness for him to read a printed book.

The Peak Cavern, in Castleton Dale, is surrounded by still grander accessories. The approach to it is in itself a magnificent picture. Immense perpendicular rocks tower on either hand, bounding a rugged and gloomy defile, through which a rivulet issues from the cave,

tumbling and foaming over a limestone bed. Suddenly a wall of rock rises sheer and abrupt before the traveller, and in it may be seen the mouth of a cavern presenting the form of a depressed arch, 120 feet wide, 42 feet high, and about 90 feet deep. On entering, you observe with surprise that a colony of twine-makers have established themselves within the recess; their machinery and quaintly characteristic appearance blending not inharmoniously with the strange features of the scene. Advancing about thirty yards, you find the roof diminishing in height, the day utterly disappearing, and a deep darkness prevailing in the narrow corridor, which is but partially dissipated by the light of the flickering torches. After moving forward, with bent head, for some thirty yards, you come upon a spacious opening, which admits you to the margin of a lake called the First Water, the surface of which the overhanging rock, at some points, approaches within twenty inches. You cross the lake in a small skiff, and on the other side enter a vast chamber 220 feet long, 200 feet broad, and 120 feet high. Then, on the brink of the Second Water, are seen the piled-up masses of rock, named, in allusion to the incessant percolation of water from the roof, Roger Rain's House; beyond which opens another recess, the Chancel, whose walls are resplendent with stalactitic incrustations. Here you will be welcomed by a chorus of wild and portentous noises issuing from the upper regions, where a group of women and children are stationed for the purpose.

Passing the Devil's Cellar and the Half-way House, the path leads beneath three natural arches to another

great cavernous hollow, so like a gigantic bell that it has received the appellation of "Great Tom of Lincoln." From this point the vault diminishes in height, and the passage contracts, until it becomes nothing better than the narrow channel of a rippling streamlet. The total length of this grand excavation is 2250 feet; its depth, from the surface of the mountain, about 620 feet. An impressive effect is here produced by the explosion of a small charge of gunpowder compressed into a crevice of the rock; the report reverberates along the roof and sides like a continuous peal of thunder among the Alpine valleys.

GROTTO OF ADELSBERG.

The celebrated Grotto of Adelsberg, which measures about two leagues in length, is one of the great natural curiosities of Carinthia. It is open at the lower part of a basin which probably formed of old a lake of some extent; the waters of the lake have gradually ebbed away through this opening, which they have enlarged, and all that now remains of the ancient condition of things is a little river—the Poyk or Pinka—which furrows the bottom of the valley, and, following the old water-course, empties itself into the cavern. Of the cavern, however, it does but occupy a part, so that a broad and convenient passage is left in the interior for the convenience of the curious.

At a certain distance from the entrance the cavern branches out into galleries so narrow that it becomes impossible to penetrate further; only the gliding waters, and the animal forms which tenant them, can force their way into its unexplored depths.

So much of the grotto as is accessible may justly be termed magnificent. It may be doubted whether any other cavern in the world equals it in grandeur and boldness. The irregularities of its surface, the distorted rents of its immense walls, its black colouring and deep shadows, form a striking contrast with the regular beauty and symmetrical grace of the white, transparent concretions suspended to the roof, which reflect on every side the glare of the burning torches.

In the waters of the little stream which traverses this cavern is found the curious animal known to naturalists by the name of *Proteus anguinus*, or the Snake-like Proteus.

Sir Humphrey Davy thus describes it :—

“At first view you might suppose this animal to be a lizard, but it has the motions of a fish. Its head and the lower part of its body all bear a strong resemblance to an eel; but it has no fins, and its curious branchial organs are not like the gills of fishes. They form a singular vascular structure, almost like a crest, round the throat, and they may be removed without causing the death of the animal, which has also lungs. With this double apparatus it can live either in or out of water. Its fore-feet resemble hands; but they have only three fingers, and are too feeble to be of any use in supporting the weight of the animal, while the hinder-feet have only two claws or toes.”

The proteus is of a pale flesh-colour, or nearly white, with three pairs of scarlet branchiæ on each side of the neck. It attains a length of about a foot, and has two pairs of weak limbs, of which the anterior have three toes,

and the posterior only two. From its habitat, the faculty of vision must be quite unnecessary, and, as a matter of fact, the eyes are altogether rudimentary, and are covered by the skin. Several varieties of proteus are known.

The proteus was discovered in the subterranean waters of the Laybach, by the German baron Zoïs ; and it has since been found at Sittich, thirty miles from Adelsberg, in certain waters which are cast out from a cavity. Rare in dry seasons, these proteuses return in great abundance after a period of heavy rains.

GROTTOES OF SASSENAGE.

The Fountain of Sassenage, in Dauphiné, situated near the extremity of the valley of Graisivaudan, enjoys almost as widespread a celebrity as that of Vaucluse.

Sassenage itself is a small town, in the heart of a charming landscape, about six miles west of Grenoble. It is the *Tivoli* of the inhabitants of Grenoble, and its beauties attract an incessant stream of visitors. Not that the town itself is interesting : it is the scenery which surrounds it. It lies at the foot of lofty and romantic rocks, at the mouth of a picturesque ravine, down whose steep declivities the torrent of the Furon pours in a succession of noisy cascades.

The famous caverns are at a short distance from the town ; they are reached by a toilsome and difficult path.

The vastest and most remarkable opens at the base of a perpendicular cliff ; it is square in form, and singularly symmetrical. From its recesses spring three abundant streams, with waters tumbling in many a fall down natural terraces, and precipitating themselves into the

Furon. This grotto is illuminated laterally by a mysterious semi-daylight, which invests its natural decoration with a truly fairy-like aspect. It communicates with numerous other grottoes.

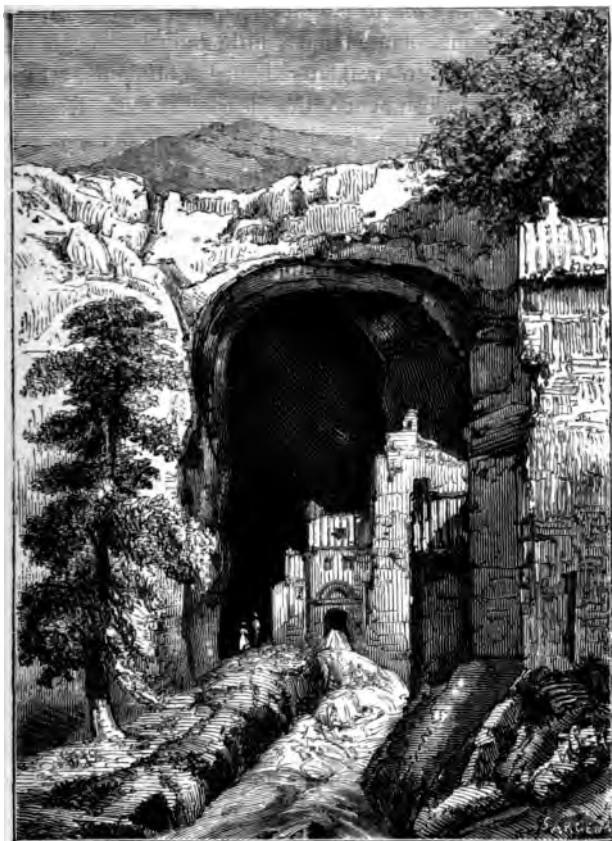
In the immediate vicinity are found the Cellars of Sassenage, which have long been regarded as one of the wonders of Dauphiné. They are shallow funnel-shaped hollows, excavated by the action of the waters in a limestone rock of singular hardness.

GROTTO OF LA BALME.

The Grotto of La Balme, one of the Seven Wonders of Dauphiné, is situated in the department of the Isère, nine leagues to the east of Lyons, and a short distance from the river Rhone. It is excavated in the heart of a hill, about three hundred and twenty feet in height, which forms part of the long low mountain-chain forming the first terrace of the Alps of Savoy and the Dauphiné.

There is a small village near the mouth of the grotto, which owes its prosperity to the great number of visitors attracted by the renown of this interesting natural marvel. Its inhabitants claim the right of imposing themselves upon tourists in the character of guides ; and the grotto itself, formerly open to every comer, and used even as a storehouse for wood, straw, and carriages, is now under lock and key, and cannot be entered until a fee has been paid for admission.

The entrance is truly majestic. Picture to yourself, obliging reader, in proportions which, though colossal, are of exceeding gracefulness, an opening like to a grand triumphal arch, whose crown consists of a burden of



ENTRANCE TO THE GROTTO OF LA BALME.

luxuriant evergreen growth. On both sides festoons of ivy and creepers are plentifully hung, and blend with the slopes of verdure and foliage which descend from the

base of the cliff even to the picturesque village. In front a cross of stone, planted on a little hillock, though intended primarily to awaken religious sentiments, serves also as an embellishment of the pleasing scene. Near at hand a young ash-tree, growing beside the pathway which leads to the grotto, stands in striking relief against the glittering surface of the cliff, as if designed to indicate its elevation. But the feature that communicates to this beautiful entrance an appearance wholly different from that of other caverns—a feature astonishing in itself—is an internal edifice which rises almost to the summit of the roof, while a torrent, issuing from the depth of the cavern, flows underneath its base, and with its shining waters enhances the picturesque character of the spectacle.

The cavern mouth measures about one hundred and five feet in height, and sixty-five feet in breadth.

As for the building within its shadow, it consists of two chapels, erected one above the other, and surmounted by a lodging for the priest who serves them, as well as by a small belfry. A broad open staircase conducts from the entrance-barrier to a platform in front of the two chapels, which are dedicated respectively to St. John and the Virgin Mary.

At a short distance from the entrance the roof lowers, and the cavern divides into two branches.

Following up the left-hand one, the visitor reaches, in the first place, the Grotto of Diamonds—a kind of labyrinth, composed of excavations more or less narrow, low or elevated, in which the waters have deposited a crystal-line sediment, which reflects and multiplies the luminous

rays. Next he arrives at an amphitheatre of small basins, which forms one of the most interesting curiosities of the grotto : these little semicircular pools pour their waters in an infinite number of miniature cascades into one another ; the incrustation which coats their bed and sides is of a dull, dead white. They have been compared to carefully wrought vessels for holy water. The most skilful chisel could hardly execute anything more perfect ; and their gracefully rounded edges form so many polished lips, terminated by regular drops of the greatest delicacy. Above these basins rises a small column, like the trunk of a tree, whose roots bulk beneath the soil in protuberances which gradually disappear. The incessant infiltrations have rounded, modelled, and ornamented this little column.

Next the visitor descends, at first along a kind of ridge, consisting of a precipitous rock, and bordered at its base with a row of drops, of about half a foot in height, so uniform in character, that they seem to have been sculptured by a skilful workman ; then by a very dangerous path, carried in and out of a number of wells or shafts, placed close together, and separated only by barriers a few inches thick. These wells, square or triangular in form, and four to eight feet deep, are surrounded by a slippery miry soil, which renders the passage very difficult. Visitors have need to make good use of their hands, to help one another, and to tread cautiously, lest they should experience a disagreeable fall.

Next, by a smooth and gentle incline, the explorer reaches a tranquil limpid lake, which dazzlingly reflects the gleam of his torches. The vault which covers it may

be from twelve to fifteen feet in breadth, and of an equal length. This lake is not so considerable as it seems : *its* greatest width does not exceed twenty-five feet, and its depth, which varies greatly, nowhere overpasses fourteen. A boat large enough to contain several passengers enables the curious to indulge in a subterranean voyage.

Mezeray, in his "Life of Francis I." (1548), relates that this monarch promised to pardon two criminals if they succeeded in exploring this lake to its very extremity. Unless we doubt the historian's veracity, we must necessarily believe that its dimensions formerly were much more considerable than they are at present. Adjoining this basin are some excavations remarkable for their extent, the variety of their forms, and their multiplicity : some are shaped like funnels ; in all we meet with a very fine sand, furrowed as if water had recently rippled over it.

We must now retrace our steps with the view of visiting the second branch of the grotto, which, as we have said, diverges from the extremity of the great vestibule where the two chapels are situated. It stretches away to the right of the branch which leads to the lake, and to its very end preserves a tolerable breadth. From the smooth, level, and rounded configuration of the soil, we may conclude that it was at one time the bed of a lake. After a few minutes' walking we reach, by a tolerably easy road, a stalagmite, nearly six feet high, whose fantastic form has procured for it the designation of the "Capuchin." Assuredly it *does* bear some resemblance to a body surmounted by a hooded head. The waters have carved

out the folds of the robe, and the side is so arranged as to represent a sleeve.

Advancing further, we reach the Bats' Cave ; so called from the number of those hybrid animals which formerly found in it a "local habitation." It is now so frequently visited, that the bats have preferred to withdraw to a less accessible retreat. At the extremity of the cavern hangs a very remarkable stalactite ; it forms a large polygonal basin, in whose centre rises a rounded mass, like a pillar intended for the support of the roof. The water which percolates through the rock keeps the basin full.

But in truth every part of this magnificent grotto is enriched with calcareous concretions of the most fantastic forms. They are so picturesque and so various, and the shifting lights produce such wayward, capricious shadows, and so enlarge each object, that the imagination is very easily excited : the spectacle before our eyes is so novel and so extraordinary, that we become as impressible as children, who, in the darkness, see ever so many phantoms and illusions, to be dissipated as increasing years bring calmer judgment. They who have read the brilliant fancies of Ariosto, however, or have endeavoured to realize for themselves the magic caves and mysterious retreats described in the "Arabian Nights' Entertainments," cannot fail to be much moved by the curious and striking scenes which this grotto everywhere presents.

Before taking leave of it, we must briefly refer to a series of very narrow excavations, varying from seven to twenty-one feet in height. Their great number, and the exact resemblance of their openings, form a kind of laby-

rinth, into which it is very dangerous to venture without an experienced guide. These are called the "King's Chambers."

THE TOFIÈRE.

The Tofière, or Grotto of the Doubs, is a natural cavern, situated in Switzerland, in the canton of Neuchâtel, and not far from the village of Brenets.

The Doubs rises in a cavern situated on the frontier of France and Switzerland, near Mouthe, at an elevation of upwards of three thousand two hundred feet above the sea-level. It flows in the immediate vicinity of the Tofière. It is even conjectured that it formerly traversed its recesses, and that this remarkable grotto is in fact the ancient bed excavated by the river in the heart of the mountain.

The Tofière enjoys a great local reputation ; it attracts a considerable number of visitors, and is, indeed, well worthy of being explored. Moreover, the surrounding landscape has a magical charm for the poetic mind or the artistic taste. The river flashes and gleams through the embowering foliage of secular woods, while the mass of precipitous rocks, in which the grotto is excavated, has a most imposing aspect.

On the face of the rock, just above the grotto, may be deciphered a couple of inscriptions recording the visits paid by Frederick William III. of Prussia, in 1814, and of Frederick William IV., in 1842. On these occasions the Tofière assumed a festal appearance—the young maidens of Brenets, attired in white, offering the sovereign flowers and a collation.

You may see, too, on the sides of the grotto, the names

and dates engraved by modest tourists in commemoration of their adventurous explorations. Their great number and their variety show how many curious individuals have made it the goal of their pilgrimage.

SUNDRY CAVERNS EXCAVATED BY SUBTERRANEAN CURRENTS.

We might still enumerate a long list of grottoes and caverns, whence streams and rills destined to swell into powerful rivers, or to lose themselves in marsh and swamp, issue in leaping and tumbling jets, or in noisy cascades.

In the department of the Doubs, for example, which, like a natural amphitheatre, slopes from the Jura towards the ocean, we might dwell upon the grottoes of Néron, Arcier, Verneau, the Mouillère of Bief-Sarrazin, Bonnevaux, Glan, and Badevel. Moreover this district contains numerous caverns no longer traversed by water-courses, which present, either in their interior or at their mouth, unmistakable traces of the former transit of the waters.

In the same countryside, the impetuous Loire rises in the recesses of a cavern, and its source appears to be in reality the outflow of the waters engulfed in the highlands of Pontarlier and the neighbouring cantons. The valley of the Loire gives birth to several petrifying streams, which deposit calcareous incrustations analogous to the stalagmites formed in the surrounding caverns.

A brook escapes from a cavern situated in the same province, which is locally known as the Balme-Epy, and

its source, formerly venerated by the Gauls, is even at this day the object of a semi-religious *cultus*.

In the department of the Jura the Seille issues from the Grottoes of Beaume-les-Messieurs, and the Cuisaille from the Grotto of Planches-sur-Arbois.

The Dessoubre leaps, in violent and distinct jets, from numerous crevasses in the limestone rocks, and forms at its source a series of cascades which human industry has utilized. The rolled pebbles which form the flooring of several neighbouring grottoes seem to indicate that waters as powerful, if not the same, anciently traversed them.

The Drugun issues also from a cavern. This river, whose motion is not ordinarily remarkable for its velocity, has, however, its occasional fits of violence. After the rainy season it forms a lake which gradually disappears through the absorption of its waters in numerous subterranean chasms, whereupon the soil is again capable of cultivation.

The Lison, the Cusancin, the Luzine likewise originate in crevasses of the limestone rocks; and in a valley above the source of the Lison may be seen the upper waters of a stream, which suddenly plunges "beneath the surface." In the sides of the funnel-like cavity which receives them may be distinguished a number of fissures, like the mouths of furnaces, each vomiting forth a jet of water when the rains have been abundant.

The small lake of Grand Saz, in the territory of Servin,

penetrates into one of the caverns, with which the great mountainous rock that borders it is pierced.

The Rhone also may be cited as an example of subterranean hydrography: the *Perte du Rhône* is famous as a national curiosity. The river is suddenly engulfed at a point to the west of Geneva, to reappear some distance lower down. When the waters are tolerably low, the whole stream is absorbed for about one hundred and twenty yards; but the Italian Government, to facilitate the transit of the timber-rafts, has blown up a considerable portion of the covering rocks, and thrown open the channel.

The Meuse is similarly engulfed at Bazoilles, and does not make its reappearance until it has flowed underground for about six miles.

The river De la Lys, in Belgium, precipitates itself into the grotto of Han, whence it emerges at a distance of sixteen hundred and fifty feet.

Similar phenomena distinguish the course of the Tille, Suzon, Aros, and Eure. The Venelle, in the department of Côte-d'Or, and the Guadiana, in Spain, are absorbed for a considerable space in marshy meadows, to reissue with augmented volume. Hence the Spaniards are accustomed to speak of the "great bridge where they can pasture a hundred thousand horned cattle."

The Dromme, which unites with the Eure in the

department of Calvados, empties itself, at some distance from the sea, into a cavity, thirty-nine feet in diameter, known as the *Fosse de Soucy*. Before it reaches this point, it has already lost a portion of its waters in the other hollows occurring in its bed. Some fresh-water springs on the sea-shore are supposed to be connected with its subterranean course.

In England, a similar phenomenon is observable in connection with the river Mole, near Boxhill, in Surrey. In very dry seasons it entirely disappears, from Burford Bridge until within a short distance of Leatherhead ; that is, for nearly three miles of its course. The places where it is absorbed beneath the surface are called "swallows," and through these crevices the water rushes with considerable velocity.

According to Dr. Mantell, this phenomenon is attributable to the cavernous nature of the subsoil over which the river flows. The vale of Boxhill, like the other transverse outlets of the chalk of the North Downs, has evidently resulted from an extensive fissure produced in the strata while they were being elevated from beneath the waters of the ocean which once covered them. A chasm of this kind must have been partially filled with loose blocks of the chalk rock, the interstices being more or less occupied by clay, marl, sand, and other drift brought down by the floods which traversed this gorge, and found their way to the vale of the Thames.

Disappearing, or intermittent, streams, dry in summer but full in winter, are common in Kent and Hampshire :

in the former county they are called *nailbournes*, and in the latter *lavants*.

Watercourses which have their origin in caverns are



NATURAL BRIDGE OF ICONONZO.

numerous enough in England, but principally abound in the counties of Northumberland, Westmoreland, Stafford, and Derby ; that is, in the old limestone formations.

Several of these streams are navigable for a portion of their course. The Manifold, in Derbyshire, after a subterranean flow of nearly four leagues, issues forth again in the daylight. In the cave of Dunold (Lancashire) a cascade descends from the vault, and forms several minor falls before emerging from the grotto.

When the caverns in which the streams disappear are



NATURAL BRIDGE OF VIRGINIA.

of small extent, and open at both extremities, they form *Natural Bridges*. These are frequently met with now in localities where no waters exist. A remarkable curiosity of this kind occurs in the valley of Icononzo or Pandi, in Mexico. It spans a chasm 325 feet deep, at whose bottom winds a small torrent, the *Rio de la Summa Paz*, enclosed in an almost inaccessible channel. The principal bridge measures 48 feet in length by 39 feet in width,

and is $6\frac{1}{2}$ feet thick. Sixty-five feet below this first bridge is found a second, consisting of three blocks, which support themselves without any adventitious aid ; the central is perforated with a hole, through which the bottom of the abyss is visible.

The Bridge of Arc, over the river Ardèche, is a natural arch, 98 feet in height, and 195 feet in span. The



NATURAL BRIDGE OF AIN-EL-LIBAN.

bridge of Veja, near Verona, is 125 feet high. The magnificent rock bridge of Virginia, in the United States, spans an abyss which separates two mountains ; an abyss 225 feet deep, in the deep obscurity of which whiten and seethe the restless waters of Cedar Creek. This marvellous arch is nearly 100 feet in length, and 42 feet thick ; it is a natural curiosity, which no spectator can survey without feelings of admiration.

In the Lebanon, a torrent, emptying itself into the Beirut river, passes under a natural arch of 215 feet in height, locally known as the *Ain-el-Liban*.

A similar bridge is thrown over the Litany, the ancient *Leontes*, near Tisr Kürdone, where the river has tunnelled through a rock upwards of 90 feet thick. The road from Wady et Teim to Nihah is carried across this wonderful arch.

The arch over the Dog River, near the Niba el Liban, spans a tremendous ravine, hollowed out in the solid rock. It is 90 feet thick ; its span, 157 feet ; and the height on the lower side nearly 200 feet.

STALACTITIC GROTTOS.

GROTTO OF ANTIPAROS.

The vastest and most magnificent of all the Stalactitic Grottoes in the world would seem, by general consent, to be that of Antiparos.

The island of Antiparos (or Antiparo), in which this famous cavern is situated, lies opposite that of Paros, in the Greek Archipelago. It measures about sixteen miles in circumference, and is identical with the *Oliarus* of antiquity, described by Pliny, Strabo, and Heracleides.

As for the grotto itself, it does not appear to have been visited by the ancients. No notice of it occurs in Pliny, who would hardly have failed to speak of it had it been as celebrated as some writers affirm. We do not think it was unknown, however ; and, indeed, the names of some Greeks who probably descended into it may be traced in a much-worn inscription of great antiquity.

At all events, the inhabitants of the island had lost all recollection of it, or were deterred by superstitious fears from penetrating into it, when, in 1673, at the end of the month of December, the Marquis de Nointel, French ambassador to the Sublime Porte, explored its recesses with a numerous train of attendants. He caused mass to be celebrated in the immense hall which terminates its subterranean labyrinth; a large and magnificent stalagmite* served as altar, and still retains the name.

Tournefort, the distinguished botanist, furnishes the

* *Stalactites* and *stalagmites* are those diversely and capriciously formed concretions which ornament calcareous caves and grottoes. They are deposited in the following manner: Through the fissures, frequently imperceptible, occurring in the roof of the cave, infiltrations of water, heavily charged with the lime which it has taken up in traversing the limestone strata, make their way. This water falls, drop by drop, on the soil of the grotto and evaporates, depositing the lime which it held in solution. These successive deposits overlying one another an infinite number of times, accumulate in a kind of pyramid which gradually increases in elevation; this is called a *stalagmite*. On the other hand, it happens frequently that the drop of water, not being heavy enough to fall, evaporates, and leaves its deposit on the *roof* of the ceiling: the same phenomenon then occurs, but in an inverse direction; that is, the pyramid is formed, but its base adheres to the roof, and its apex points downward; this is a *stalactite*. Finally, when the two phenomena occur simultaneously in connection with one and the same crevasse, the upper and the lower pyramid, the stalactite and stalagmite, join together, and form a single column.



STALACTITES AND STALAGMITES.

following graphic description of M. de Nointel in the grotto of Antiparos :—

“M. the Marquis de Nointel,” he says, “celebrated three Christmas festivals in this grotto, accompanied by more than five hundred persons, either members of his household, merchants, sea-rovers, or peasants: a hundred great wax-tapers and four hundred lamps, which burned day and night, were so skilfully arranged that the scene was as bright as a church illuminated in the same manner. Men were posted at intervals in every recess, from the altar to the mouth of the cavern; they signalled with their handkerchiefs when the host was elevated. Then eighty canisters and several cannon which were ranged at the mouth of the cave were fired off; and trumpets, hautboys, fifes, and violins rendered the celebration one of singular magnificence.

“The ambassador passed the night, almost opposite the altar, in a kind of cabinet, seven or eight paces long, excavated naturally in the solid rock. Close at hand may be seen a shaft or tunnel, through which you enter into another cavern, but no one durst attempt the descent.

“Much difficulty was experienced in bringing from the village a supply of fresh water sufficient for so large an assemblage. The Capuchin almoners of his Excellency were not armed with the rod of Moses. After a long search, a fountain was discovered to the left of the ascent; a little basin in which water had gradually accumulated by percolation.

“In M. de Nointel's suite were two skilful artists, and three or four masons with the necessary tools for detaching and removing the heaviest marbles. He carried away a host of beautiful articles, which figure at present in the Museum of Natural History at Paris.”

Tournefort himself descended into this grotto some twenty years later; and published a description of it, which is very graphic, but unfortunately not free from exaggeration, and disfigured by the obtrusion of a most

singular theory in reference to the formation of calcareous concretions.

In 1780 the grotto was visited by the Comte de Choiseul Gouffier, whose narrative is in every respect praiseworthy, and entirely devoid of sensational colouring.

Since then, it has been annually explored by a great number of strangers, and it now occupies a foremost place among the natural curiosities and beauties of Greece.

The Grotto of Antiparos is situated about a mile and a half from the sea, opposite the islands of Nio, Sikino, and Policandro.

The entrance is a vault of rocks of inconsiderable elevation and without any imposing features : a natural column rises in the centre, to which is attached a rope, for the double purpose of assisting the traveller's descent and facilitating his return.

Afterwards we move towards the right hand, but almost immediately turn round and wheel to the left, following a gentle incline which carries us beyond and below the column already spoken of. At this point we come upon an excavation, and seizing the rope, we allow ourselves to drop down upon a platform six or seven feet deep ; being the "precipice" which Tournefort calls "horrible."

Having accomplished our descent in safety so far as the little platform, we again trust ourselves to the rope, and by a very steep incline sink some twelve fathoms lower. We then come to the most difficult part, and the only part which is really dangerous. It is a rock, the summit of which is rounded almost in the shape of a

dome : the water, falling in all directions, renders it exceedingly slippery. On the right sink abrupt precipices, whose depth cannot be determined in the darkness ; while the inclination of the rock towards the abyss is so great that those not clinging stoutly to the rope, and carefully preserving their equilibrium, would be dashed headlong. In this way we descend twelve or fifteen feet further.

When we have achieved this passage, we continue to descend by a path which is still exceedingly abrupt, but much broader ; but it is possible to keep towards the left, and at a distance from the precipices. The descent at length grows less rapid, and after awhile the assistance of the rope becomes superfluous. The roof at this point is considerably higher, but the exact height is difficult to ascertain, the torches throwing out only a pale and restricted light on account of the fog always prevailing in these subterranean places, which is much augmented by the smoke of the torches.

After doubling a huge rock, which at first sight seems to block up the passage, we finally enter the grand hall, which terminates our exploration.

Although the grotto of Antiparos may be, as we have said, the most remarkable of all the known caves of the world, it does not altogether answer to the pompous descriptions of enthusiastic travellers, who speak of it as if it were the palace of the Sun, and burst into transports when they allude to its crystal architecture, with its sheeny surfaces varying, reflecting, and multiplying the radiance of the torches. " You would think yourself transported,"

says one of them, "into the grottoes of Thetis on the bridal day of Peleus."

The pretext afforded for these exaggerated narratives, and the circumstance that invests this grotto with peculiar interest, is the magnificent and innumerable host of concretions which it contains, with their varied forms, and the surprising contrasts of their uncertain outline. We may here remark, however, that most of the columns formed in this grotto have been broken by curious and irreverent visitors, in their desire to carry away, at any cost, some memorial of their adventure.

The Altar is a superb stalagmite, about twenty-four feet high, and, at its base, nearly twenty feet in diameter. The following inscription may still be traced upon it:—

HIC IPSE CHRISTUS ADFUIT EJUS NATALI DIE, MEDIA
NOCTE, CELEBRATO MDCLXXIII.

It commemorates the mass performed here, in 1673, at midnight, on Christmas Eve.

Other concretions, pendent in long curtain-like folds, are of such thinness that the skilful adjustment of a few torches renders them quite transparent ; but this light, or rather *glimmer*, is always without brilliancy. Whatever forms the concretions assume, they are all dull and opaque. Their outer surface is generally rugged, irregular, and worn by atmospheric influence.

The slow and progressive growth of these concretions by concentric layers suggested to Tournefort his absurd theory of the vegetation of stones—a theory which will not bear a moment's investigation. There is to be seen,

he says, a large pavilion, or tent, composed of productions so exactly representing the roots, ramifications, and inflorescence of cauliflowers, that it seems as if Nature had wished to show us the processes by which she works in the vegetation of stones. All these figures are of white marble, transparent and crystallized, which, when broken, splinters up into layers. Most of these stones are covered with a kind of white crust, and, when struck, ring like bronze. Describing a stalagmite wrought in the shape of a column, he compares it to the trunk of a tree which has been cut through transversely. "The middle," he says, "represents the pith or woody core of the tree; is of a brown marble, about three inches broad; and surrounded by several rings of different colours, or rather, so many old *aubiers*, distinguished by six concentric zones, each about two or three lines thick, whose fibres radiate from the centre to the circumference. It appears that these marble trunks vegetate; for besides that in this particular locality not a drop of water falls, it is not conceivable that drops falling from a height of 150 to 180 feet should have been able to form the cylindrical, dome-like specimens, whose regularity is nowhere interrupted." Of some other pyramidal concretions he remarks, that they are perhaps the most beautiful marble plants in the world; and from thence he proceeds to deduce the most erroneous inferences as to the mode in which minerals are reproduced.

At the bottom of the cavern, which serves as a vestibule to the grand grotto, lies another and smaller one—the Cave of Antipater. It is entered through a square opening, like a window.

The Cave of Antipater is completely incrustated with crystallized and *corrugated* or fluted marble. It is a kind of saloon, level with its opening, which would please the visitor greatly did he not come to it dazzled by the marvels of the great grotto.

The shoulder of the mountain in which these curiosities occur is paved, as it were, with brilliant bits of crystal, also of a calcareous nature, which invariably break up into lozenge-shaped fragments. These crystallizations perhaps indicate the proximity of other subterranean marvels.

GROTTO OF THE FAIRIES, OR DEMOISELLES.

One of the most celebrated and magnificent stalactitic grottoes in France is situated in the canton of Ganges, department of the Hérault. It is known by various appellations—as, for instance, the *Grotto of La Baume*; the *Grotto of the Fairies*, or Demoiselles; and, locally, the *Bauoumas de las Doumaïsallas*.

The peasants living in the neighbourhood assert that at the epoch of the civil wars, which so long desolated Languedoc, a great number of Huguenots sought refuge in this cavern. They pretend even that a family of these unfortunate refugees continued to reside here, generation after generation, until towards the close of the last century, availing themselves of the superstitious fears it excited throughout the countryside. The latest descendants, however, barely supported a miserable existence by carrying off the goats which ventured into their vicinity. They had sunk into an almost savage condition; had even forgotten the use of clothes—so that, at a distance.

they resembled spectres, and were the terror of all the simple country people round about. And it is true that the first explorers who visited the Fairies' Cave found some skeletons in it, as well as a few rudely-fashioned utensils.

It was not until 1780 that any person found courage to penetrate into the recesses of this cavern, though the first part of it, being readily accessible, had often been explored. On the 7th of June 1780, Marsollier, with a few companions, made the first attempt to descend into the grotto, but without result. On the 15th of July, he returned, with a larger number of attendants, and an abundant supply of ropes, ladders, hammers, hand-grenades, and provisions. They proceeded in safety to the furthest extremities of the cavern, where they deposited a bottle, hermetically sealed, containing an account of their exploration, and a small leaden plate on which their names were inscribed.

Marsollier has published a description of the grotto, but it is no longer perfectly accurate in its details. The configuration of the stalactites and stalagmites has been greatly modified, and even the appearance of the grotto has undergone much change, since Marsollier's visit.

The entrance of the Fairies' Cave resembles a well or shaft, measuring about twenty feet in diameter. Its margin is edged and banked up with stones, covered by the spreading branches of the wild vine. At first we descend for about twenty feet, clinging to whatever shrubs, bushes, and projections we can find. Afterwards, with the help of a rope, we allow ourselves to drop as far as a gloomy

cavity, completely surrounded by lichens and ferns, with a great stalactite pendent from the roof, which seems to mark the actual threshold of the subterranean. A few yards, and we pass under a kind of sombre and majestic propylæum, which, without much effort of the imagination, says a traveller, might be mistaken for the portico of the palace of some genius of the earth. Soon afterwards we plunge into a series of large halls, which cross and ramify in different directions, and in which we discover a multitude of curious forms, of marvellous freaks of Nature, such as one might suppose to be the rude artistic efforts thrown aside and accumulated in the immense workshop of some giant sculptor.

And, first, we remark a kind of huge pedestal, supporting numerous busts; then, a multitude of columns, and draperies, and bundles of lances, which sparkle and shine for a moment in the glare of the torchlight, soon to subside, as it were, into the gloom of black marble. All the walls and roofs seem modelled with the design of presenting a monstrous combination of all the known styles of architecture: Roman, Moorish, and Gothic seem to dispute for predominance in the confusion. Here the columns are slender, shapely, and wreathed with festoons; there they assume all the solidity of those of Pæstum; here, again, they taper like the palm-trees of the Nile: arches, pyramids, undulating tapestries, embroideries finer than the finest lace-work, masses of uncertain configuration, large and small, single and aggregated, all white as milk, and all capable, by a lively imagination, of being converted into shapes of women, and gnomes, and fairies—some rising from the soil, some

starting from the walls, some suspended to the ceiling. Add to all these strange and various objects the air of movement, communicated by the waving light of the torches, and the reader will understand that the scene, in its dreary silence and solitude, cannot fail to produce a very deep impression.

A circular gallery leads to a cell, with a very low roof, called the Baker's Oven. The passages become narrower and narrower. We pause a moment on the brink of a shaft the depth of which has not been ascertained, but from which we feel a current of air ascending. Then we pass on, and on, through long, gloomy corridors, until we reach a smooth-surfaced compartment, without stalactites, where the miry soil is thick crusted with the ordure of innumerable birds of night, which find there an asylum; building their nests in the fissures, or clinging to the roof, and overspreading it with their broad black wings. We leave this cavity by an exceedingly narrow passage, and enter into a double colonnade. Behind these pillars is a small basin of excellent water; but we move forward to a shadowy excavation, embellished and crowded with stalactites, which seem interminable.

Here begins the second part of the grotto.

To enter, it requires, undoubtedly, a certain amount of courage; for we are forced to descend a ladder sixty feet long, which our guides attach to a projecting crag. Now the ladder rests upon a stalactite for twelve or fifteen feet only; all the rest of its length it is without support. Marsollier acknowledges that when descending

this long moving ladder, in the shade and gloom, on the occasion of his first visit, he nearly swooned.

We land upon a solid platform, abutting on a second precipice, which we accomplish by sliding along the rock, clinging with our hands to every protuberance, and afterwards by means of a rope fixed almost horizontally to two iron rings. To this locality has been given the formidable name of the *Pas du Diable* (or Devil's Step).

Another inclined plane offers still greater difficulty. However, with the help of a cord, stretched vertically, our body is suspended above an abyss, our hands glide cautiously along the cable, and the feet grope about to find some holdfast or support on the ledges of the rock. At length we reach a solitary height, barely broad enough for a man to stand upon.

The last effort is to cross a rounded rock, covered with stalagmites, which we have to grasp with all our might, to prevent ourselves from a headlong descent.

But, these difficulties overcome, we are amply recompensed. Before us expands a cavern whose elevation is not less than 300 feet. Enormous groups of stalagmites, like clouds; a conical needle, resembling the slender spire of a tall belfry; projecting masses, which we might suppose to be jets of water suddenly congealed; columns which rise unbroken from ground to roof, and, in the distance, seem like the shadowy forms that haunt the wild verse of Ossian,—produce a powerful influence on the imagination. In certain parts, the stalactitic concretions, which encumber the ground, present the spectacle, now of a ruined temple, now of an immense

necropolis. No picture could furnish any satisfactory presentment of the strange and marvellous scene.

However, through the chaos of stalagmites, one shapely figure rises majestically, whose every line is instinct with grace. It seems like a statue of colossal yet exact and enticing proportions. From whatever side we view it, it presents the same appearance. The guides call it "the Virgin."

On issuing from this grand hall, we perceive that the grotto extends still further. A circular cavity, with a central pillar, is named the *Manège*. Here we notice a curious concretion, resembling a white bear in appearance.

There are numerous other beauties in this fine grotto ; but their very multiplicity, and the protracted nature of the exploration, eventually exhaust the attention. Curiosity insensibly but gradually grows weary : we cease to feel admiration or express surprise ; we long for the light of day.

New difficulties are experienced on the return. We are better acquainted with the danger, and are no longer sustained by the sentiment of the unknown. When, at length, we arrive in the open air, we breathe more easily. We feel as if we had awakened out of a dream, and had once more regained our senses in the actual world.

THE GROTTOES OF ARCY.

The Grottoes of Arcy are situated in the department of the Yonne, near the village of Arcy-sur-Cure, in the district of Vernanton. They appear to have been known at an early period, for inscriptions dating from

teenth century have been found in them. Col-
 on the spot a description of the minutest ac-
 ch the reader will find embalmed in *extense*
opédie of Diderot and D'Alembert. Buffon
 1740 and 1759, and wrote an account of
 stating them in order to enrich with
 official grottoes with which he purposed
 in the *Jardin des Plantes* of Paris. Dorat, the
 of affectation and namby-pambyism, thought them
 not unworthy of his muse :—

“ Ces beaux salons de rocailles ornés,
 Sans le secours de l'art, avec art ordonnés ;
 Ces magiques piliers dont la cime hardie
 Observe en s'élevant l'exacte symétrie ;
 Ces rocs, qui des rubis dardent tous les rayons ;
 Ce buffet d'orgue prêt à recevoir des sons ;
 Ces ifs qui, sans les soins d'une vaine culture,
 S'échappent tout taillés des mains de la Nature.”

Finally, a number of other illustrious or well-known
 personages have visited, at more recent epochs, the
 grottoes of Arcy ; and nowadays every traveller who
 crosses the Morvan devotes one day, at least, to the ex-
 ploration of this marvel of the ancient Duchy of Bur-
 gundy.

The total length of the grottoes is nearly three thou-
 sand feet. They consist of a series of lofty and spacious
 chambers or cavities, separated by passages or ravines
 of varying length, which are sometimes so low and so
 narrow that you can force your way through them only
 on your hands and feet.

We reach the spot by a very narrow pathway, which
 winds up the ascent of a finely-wooded hill.

The entrance is situated at the base of a large and
 (501)

necropolis. No picture could furnish any satisfactory presentment of the strange and marvellous scene.

However, through the chaos of stalagmites, one shapely figure rises majestically, whose every line is instinct with grace. It seems like a statue of colossal yet exact and enticing proportions. From whatever side we view it, it presents the same appearance. The guides call it "the Virgin."

On issuing from this grand hall, we perceive that the grotto extends still further. A circular cavity, with a central pillar, is named the *Manège*. Here we notice a curious concretion, resembling a white bear in appearance.

There are numerous other beauties in this fine grotto; but their very multiplicity, and the protracted nature of the exploration, eventually exhaust the attention. Curiosity insensibly but gradually grows weary: we cease to feel admiration or express surprise; we long for the light of day.

New difficulties are experienced on the return. We are better acquainted with the danger, and are no longer sustained by the sentiment of the unknown. When, at length, we arrive in the open air, we breathe more easily. We feel as if we had awakened out of a dream, and had once more regained our senses in the actual world.

THE GROTTOES OF ARCY.

The Grottoes of Arcy are situated in the department of the Yonne, near the village of Arcy-sur-Cure, in the district of Vernanton. They appear to have been known at an early period, for inscriptions dating from

the thirteenth century have been found in them. Colbert wrote on the spot a description of the minutest accuracy, which the reader will find embalmed *in extenso* in the *Encyclopédie* of Diderot and D'Alembert. Buffon visited them in 1740 and 1759, and wrote an account of them, after devastating them in order to enrich with their spoils the artificial grottoes with which he purposed to embellish the *Jardin des Plantes* of Paris. Dorat, the poet of affectation and namby-pambyism, thought them not unworthy of his muse :—

“ Ces beaux salons de rocailles ornés,
 Sans le secours de l'art, avec art ordonnés ;
 Ces magiques piliers dont la cime hardie
 Observe en s'élevant l'exacte symétrie ;
 Ces rocs, qui des rubis dardent tous les rayons ;
 Ce buffet d'orgue prêt à recevoir des sons ;
 Ces ifs qui, sans les soins d'une vaine culture,
 S'échappent tout taillés des mains de la Nature.”

Finally, a number of other illustrious or well-known personages have visited, at more recent epochs, the grottoes of Arcy ; and nowadays every traveller who crosses the Morvan devotes one day, at least, to the exploration of this marvel of the ancient Duchy of Burgundy.

The total length of the grottoes is nearly three thousand feet. They consist of a series of lofty and spacious chambers or cavities, separated by passages or ravines of varying length, which are sometimes so low and so narrow that you can force your way through them only on your hands and feet.

We reach the spot by a very narrow pathway, which winds up the ascent of a finely-wooded hill.

The entrance is situated at the base of a large and

lofty vault, which contracts with some abruptness, and terminates in a kind of little gate about four feet high, so that one cannot pass into the interior except with head and shoulders bent.

But the threshold crossed, we find ourselves in the first hall, the Hall of the Great Desert, whose roof is perfectly smooth and level.

From this hall, which inclines with tolerable rapidity, and is remarkable only for the enormous blocks of stone which partially obstruct it, we penetrate, by the so-called *Passage de Madame*, into another and much more spacious chamber, fully eighty feet in length, and nine to ten feet in height. There, but principally at one point of the roof, may be seen a great number of beautiful stalactites: huge rocks, moreover, are scattered about in some, and piled together in other places; so that walking is very difficult. To the right lies a kind of lake, an almost circular basin, which may be about forty feet deep, and one hundred and fifty feet in diameter: its waters are clear, and good for drinking purposes.

On leaving the lake, we follow the *Passage de Monsieur*, and arrive in the "Hall of the Virgin;" an excavation filled with magnificent concretions, whose brilliant facets produce, in the shimmering torchlight, quite a magical effect. The roof, throughout nearly its whole extent, is ornamented with bosses of various dimensions, which all distil some drops of water from the extremity. Towards the centre of the hall a host of inverted pyramids, about the thickness of one's finger, support the roof, and seem to have been brought on purpose to ornament and enrich this recess. To the principal concretions in the hall the

names of objects to which a fanciful imagination sees in them a certain resemblance have been given: such as the Borne de Saint Irancy, the Virgin, the Shambles (*Boucherie*), the Thousand Columns. At the very end of the hall, on the right, is a kind of little grotto—the Cabinet of Monsieur—which is barely a few feet square, but is filled with such an infinite number of miniature pyramids that it is impossible to count them. In this compartment some shells are also found, of various shapes and different sizes.

The next chamber is named the Hall of Decorations, on account of the numerous concretions of all kinds with which it is embellished—such as pillars, pyramids, domes, draperies. To some of these have been given the names of the Pillar of St. James, the Drapery, the Calvary, the Tower of Babel, and the like: the last-named has the configuration of a dome, whose concavity would seem to be painted in large black flowers, with a ground of gold; but if you touch it ever so lightly, you efface these glowing colours, which are the effect only of humidity. It is here that Vandals, desirous of carrying away some souvenir of their visit, generally detach from the wall the fragments of stalactites which take their fancy: happily, however, Nature quickly repairs the damage they inflict, and removes every trace of their spoliation.

Afterwards, through the *Pas de Babylone*, we enter St. Margaret's Hall, a chamber of moderate dimensions, brightened by a little fountain.

Then we take the *Pas du Défilé*, and penetrate into a very spacious saloon, which contains few stalactites, but

numerous masses of rock, resulting, apparently, from landslips : hence this hall has been named the *Salle des Eboulements*.

What comes next ? The Dancing Hall, the most beautiful in the grotto, which measures about one hundred and thirty feet in its greatest length. It is decorated by countless stalactites and stalagmites, among which we particularly notice those designated under the names of George Pascal and Mont Saint-Jean. In the centre of the roof, which is very lofty, a swarm of bats have made their roosting-places ; but when the torchlight is thrown upon them, they flutter to and fro in hopeless confusion. Just beneath their coign of vantage is a gentle elevation : strike it with your foot, and the ground re-echoes as if there were a vault beneath. It is conjectured that the little river Cure, which washes the base of the hill containing the grottoes of Arcy, throws off a little brook, and this brooklet circulates subterraneously.

Next to the Dancing Hall comes the Hall of the Sea-Waves ; or, rather, the two seem to form but one compartment or chamber. Its name indicates the curious appearance of the multitude of stalactitic ripples which adorn its surface.

The Fox's Hole is an exceedingly narrow passage, in which the visitor is compelled to crawl along on his stomach, like the serpent of old ; it leads to a small cavity, the last in these vast grottoes.

One of the peculiarities of the grotto of Arcy is that, in opposition to the usual condition of subterranean localities, the temperature in the hottest seasons is very mild, though it has no other known opening than the

arched entrance, and one cannot descend into it, or traverse it, except by the light of torches.

We have already pointed out that Nature undertakes the task of repairing all the dilapidations committed in this cavern, and replacing all the stalactites which rude hands destroy. We may presume, therefore, that one day these grottoes will consolidate, and incessant infiltrations so increase the number of concretions that the whole will form but one compact mass.

As for the origin of the grottoes of Arcy, we may conjecture that they were formed by the river Cure, which, at a far remote epoch, may have excavated a channel through the mountain; and that some great upheaval of the soil, at a later date, diverted the waters into their present channel. And it is noticeable, in fact, that the soil still exhibits ineffaceable signs of the passage of these waters, and of the débris which they left. If we turn up the layer of stalagmite which covers it, we find underneath a thick bed of mud, and in this mud, rolled pebbles which are not calcareous like the mountain, but granitic, and, consequently, must have been carried into these grottoes by the river-current. In this same mud-stratum have also been found some fossil bones, and, particularly, an elephant's tooth. These may have been deposited by the same cause.

GROTTOES OF OSSELLES.

The Grottoes of Osselles, the most celebrated in Franche-Comté, are remarkable for their extent and depth.

Situated at five leagues from Besançon, in the territory of the commune of Roset-Fluans, they are excavated in the side of a hill of very moderate elevation, and form a succession of chambers extending to a depth of at least two thousand six hundred feet into the interior, and containing stalactites and stalagmites of the most various and fantastic forms.

The grottoes of Osselles were known and visited a long time ago. In 1763, a brilliant festival was given in them by the intendant of the province, Toulangeon. The particular section decorated for the occasion is still pointed out, and it is said, as we can well believe, that the coruscation of the stalactites in the radiance of torch and taper rendered the spectacle one of unusual magnificence.

The visitor's attention is also directed to a kind of tribune, in one of the smaller halls, where mass was celebrated, according to tradition, during the Revolution.

All the compartments of the grottoes of Osselles follow one another in orderly sequence, and the intercommunication is very easy; only in a very few places are the passages narrowed or impeded by masses of petrification. It might almost be said that they form but a single gallery. Moreover, they are generally spacious and lofty: sometimes with smooth and shining walls; sometimes enriched with stalactites and stalagmites of every variety of shape, but, in the main, cylindrical.

One of the first excavations entered by the visitor bears the name of the Bats' Hall, in allusion to the numerous cheiroptera who have made it their retreat.

Among the others, the most remarkable are denominated, in accordance with the character of their natural decorations, the Organ Chamber, the Tomb, the Cemetery, and so on.

Strange are the forms assumed by the stalactites in all these chambers : those which excite the greatest ad-



GROTTOES OF OSSELLES—THE TOMB.

miration are the Hanging Curtains, the Palm-trees, the Fountain, and the Colonnades.

Some of the stalactitic pillars are so beautiful, that the intendant Toulangeon resolved upon employing them in the embellishment of his château. He began to put his

project into execution, and some of the columns were hewn down, and by means of a car or sledge carried as far as the entrance ; the narrowness of the mouth, however, effectually prevented their being carried further.

When the visitor has penetrated into the grottoes about three-fourths of their whole extent, he comes upon a brook sunken deep in a rocky defile. This, of old, completely barred the passage, until Toulangeon, in 1763, erected a stone bridge across it.

In one of the further chambers wells forth a fountain of clear and wholesome water.

The *last* compartment is a deep cavity, whose soil and descent are covered with a fine calcareous sand. It terminates in a chasm filled with water.

In 1826, some explorers discovered, in that part of the grottoes lying between the entrance and the bridge, under a crust of stalagmite of no great thickness, a stratum of earth, in which a quantity of fossil bones were embedded, and, more particularly, the bones of the *cave-hyæna* and *cave-bear*. This discovery led to the supposition that issues must formerly have existed, which are now closed up ; inasmuch as the present entrance to the caverns is much too small to admit of the egress or ingress of animals of their magnitude.

GROTTO OF HAN-SUR-LESSE.

Han-sur-Lesse is a small village of Belgium, situated about fifteen miles from Dinant. The grotto, whose antiquity ascends far into the mists of primeval times, seems to have been excavated in the huge mass known as the *Rocher de Han*, by the little river Lesse, an af-

fluent of the Meuse, which anciently flowed round the cliff, and in the course of ages worked a channel through it.

The grotto of Han has been described by numerous authors, but they have been unable to resist the temptation of exaggerated colouring. A description, however, not less accurate than interesting, has been published by M. Philéas Collardeau, who visited it in 1864.

The entrance to the cavern is situated in a very agreeable park, whose proprietor levies a tax upon every visitor to the natural curiosity of which he claims the monopoly.

Under a low vaulted roof we make our way into the grotto, and reach the bank of the Lesse, whose noisy waters fill every echo with clamour. Then we get into a small skiff.

"We have hardly navigated the river," says Collardeau, "for a few minutes, before, in an angle of the shadowy tunnel through which we are passing, we catch sight of a huge lurid fire, which, though it does but feebly illuminate the cavern, produces a really magical effect. I thought myself transported to the Cirque-Olympique or to the Porte-Saint-Martin, at the representation of a fairy extravaganza. The *silhouettes* of two individuals were outlined near the fire: we heard, at the same time, an agreeable strain chanted by a couple of voices, and repeated by the cavern-echoes; we heartily applauded, and, a few moments afterwards, as we disembarked upon the rock, were saluted with great courtesy by the two visitors, whose shadows we had seen, and whose songs we had heard."

After a short voyage we land on the block of stone which forms the quay.

The grotto is of immense depth ; it consists of a great number of compartments, some of which are of extraordinary elevation. And almost everywhere the path we follow winds around a thousand rocks, a thousand huge



GROTTO OF HAN-SUR-LESSE.

piles of stones, heaped up pell-mell, and forming a tremendous chaos.

In stalactites and stalagmites the cavern is abundantly rich ; and here, as in similar caves, Nature seems to have amused herself in fashioning them to a certain resemblance to well-known objects, such as draperies, cascades, colonnades, human figures. Hence, according to the

character of this capricious and fanciful decoration, many of the cavities or compartments are known by familiar appellations ; such as the Hall of Beetles, the Foxes' Hall, the Frogs' Hall, the Hall of Trophies, the Chamber of the Cascade, the Chamber of the Abyss, the Boudoir of Proserpine, the Hall of the Dome, the Devil's Gallery, and the Chamber of Draperies. To bring out the transparency of some of the stalactites, the guides place torches behind them ; an arrangement which produces, says Collardeau, an effect like that of the lights placed behind the side-scenes of a stage. To complete the analogy, the sides of the grotto begin to be blackened by the smoke of the torches.

In the grotto of Han, according to the same traveller, are found many tremendous chasms, the depth of which can be estimated only by casting into them stones and burning straws ; these chasms assume the appearance of fissures, or clefts, about two feet and a half wide ; in the obscurity we cannot pass them without a shudder.

The *Trou de Han*, through which we emerge, is not one of the least curiosities of the grotto ; it appears, from the outside, like a vast funnel dipping deep into the solid rock.

The mouth of the grotto is so arranged as to produce the most curious acoustic effects, of which the guides, for a consideration, give every visitor an idea. It is impossible to imagine the terrible noise which the discharge of a fire-arm causes : all the recesses and cavities of the mountain seem to roar simultaneously, as if the whole mountain were crumbling into dust. To this terrible din soon succeeds an impressive calm, interrupted only

by the harsh cry of the bats hidden in the recesses of the cavern, or by the monotonous murmur of the waters percolating slowly through the rock, and falling, drop by drop, into the sluggish wave of the Lesse.

In visiting the grotto of Han, says Collardeau, the sensation which one first experiences is the most delightful ; for after a quarter of an hour one grows accustomed to the spectacles before one's eyes, and though the character of the cavern frequently changes, what we saw first seems always to have been the most beautiful. There is, however, a picture which we cannot help admiring ; it is presented before us when, at the end of an hour (about the ordinary limit of a careful visit), we arrive at the point of egress, and perceive the sunshine gradually irradiating the fissured walls of the grotto. The emotions we experience on regaining the light of day after this long subterranean trajet are truly indescribable ; and the opinion of every traveller who has visited the grotto is that, were it only to enjoy this last impression, there is no fatigue or even danger which one does not readily forget.

After exploring the grotto of Han, we must not neglect to visit another very curious grotto, at a distance of about 1800 feet, which is easily found without the assistance of a guide, by skirting the mountain-base and following up a covered path on the border of the wood : we refer to the *Trou de Belvoux*, into which the Lesse, after having meandered in a romantic valley, precipitates itself abruptly and with a frightful roar, forming a gulf

of unknown depth. As yet this abyss has not been fathomed.

On the 1st of September 1818, the Count de Robiano de Borsbeck, having noticed that the foam, two or three inches deep, was floating on a portion of the surface of the waters in the recesses of this cavern, had the temerity to descend into it in a washing-tub, fastened upon some planks, and held together by a rope, while another rope was passed under his arm-pits. These were held by the attendants who accompanied him ; and in this fashion he risked himself in a bottomless abyss, armed only with a pole about eighteen feet long, which he plunged with all his strength into the gulf, where it remained for a few seconds before reappearing. Whirled round and round by the current, it was soon dashed into the centre, where he remarked that the sides of the rocks sunk perpendicularly. He could discover no practicable passage, but he found two fissures filled with water, which had no apparent outlet. He vainly sounded with his pole, and could not come upon the issue through which the waters were engulfed ; he conjectured, however, that it lay a little towards the left, opposite the entrance, where he had noticed a kind of funnel, into which the river poured itself, escaping afterwards by the lateral face which looked towards the north. Our intrepid explorer was hauled upon *terra firma* safe and sound, though the water had several times entered his extemporized boat.

The inhabitants of the surrounding country, and the tourists themselves, frequently find amusement in flinging various articles into the gulf, in the hope of seeing them reappear at the point of emergence of the river. But this

hope is never fulfilled. Heavy articles sink to the bottom, and do not rise. Light articles, such as straws, carried down at first by the current, quickly return to the surface in the interior of the grotto, where the waters are calmer. But there they find their progress checked by projecting rocks or impending vaults, whose extremity, descending to the very bed of the river, allows the water to permeate underneath while arresting these objects which float upon the surface.

However, as the Abbé de Feller remarks, light articles, and those of very small size, may perhaps traverse the grotto when the level of the waters sinks below the base of these natural weirs or barriers.

MAMMOTH CAVES OF KENTUCKY.

We can have no hesitation in regarding the Mammoth Caves of Kentucky as one of the most surprising marvels of a land of marvels. In truth, it may be doubted whether the world can offer anything more wonderful "beneath the surface."

I am prepared to affirm, says a French traveller, who long and minutely explored them, that no spectacle, not even that of the Falls of Niagara, so deeply impressed me, among all the natural phenomena of the United States, as this prolonged voyage in the bowels of the earth, where, at every point, a new world seemed to open on my gaze.

These grottoes are situated in Kentucky, at no great distance from Louisville. A special station on the railway from Louisville to Nashville, around which are

erected the houses of *Cave-City*, conducts the traveller to a point within ten miles of the grottoes.

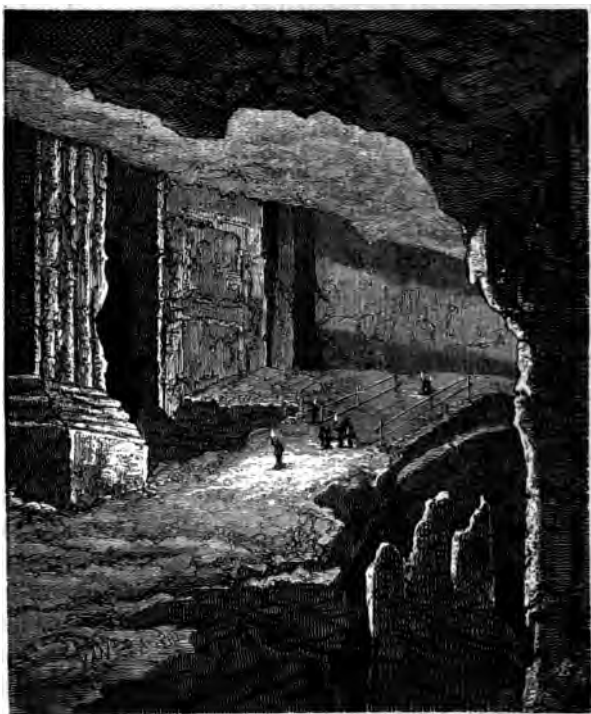
The surrounding country is rich in all kinds of geological curiosities; it is perforated with caverns, and undermined by subterranean waters; mineral springs abound, and intermittent fountains, and basins with no apparent outlet.

Shortly before arriving at the caverns we come to the Mammoth Cave Hotel, where we doff our travelling clothes and attire ourselves in a suit of stout cloth, and where we find guides, usually negroes, duly provided with miners' lamps. Then we descend by a small pathway excavated among the rocks, until we discover, in the sides of the mountain, and at the bottom of a funnel-shaped cavity, overgrown with verdure, an opening so low and narrow that two people can with difficulty enter at once, and erect: this is the entrance to the famous grottoes.

After taking the precaution of lighting our lamps, we advance into a long corridor resembling the gallery of a mine, and descend seventy to eighty steps, dripping with moisture, and excavated in the rock: then we enter another long but much loftier gallery, about seventy feet broad, which bears the illustrious name of the naturalist Audubon. It abuts upon a saloon called the Rotunda, from which a great number of corridors radiate.

One of these, the Grand Vestibule, leads by a somewhat rapid descent into a chamber nearly 320 feet in circuit, whose roof rises like the span of an immense nave. Its form, its grandeur, its magnitude (it could

accommodate five thousand persons), and the strange architectural-like stalactites which embellish it, have procured it the name of the Gothic Church.



AUDUBON'S AVENUE.

And in truth, says Deville, thanks to the power of imagination, and the varying influence of the light, we here distinguish all the details of a mediæval nave, pillars, and columns, and corbels, and ogives. There is

even a natural pulpit, from which, it is said, more than one of the natural preachers who abound in the United States have expounded their doctrines.

The Gothic Church is situated at no less than a mile and a half from the entrance.

On quitting it, we plunge into an avenue fully a quarter of a league in length, where the torchlight elicits a myriad coruscations from the sparkling stalactites.

Thence we pass on into the Chamber of the Dead (*Chambre des Revenants*), so named because some Indian mummies were found in it. It may be that this hall at one time served as the cemetery or place of sepulture of some of the tribes who formerly inhabited the American continent; despite its sinister name, it is a bright, well-lighted apartment. The wives of the guides have here established a kind of restaurant, where liquors of all descriptions are sold, and where you may read the daily newspapers.

Invalids also, and more particularly persons afflicted with chest diseases, on whom the atmosphere of these subterranean localities exercises, it is said, a salutary influence, assemble here as at a rendezvous.

But a still more remarkable object is the immense skeleton of a mammoth, almost perfect, erected in the centre of the apartment. As might be supposed, it is frequently the theme of absurd interrogatories on the part of tourists not well versed in paleontological science.

A little further and we come to a narrow corridor named the Labyrinth, whose roof is so low that the ex-

plorer must needs crawl on his hands and knees. It is not inaptly termed by some of the guides Humility Path; and as, in fact, one cannot raise one's head without striking it against the rock, the haughtiest must comport themselves with an humble demeanour.

In this way we arrive at the Gothic Chapel, a miniature



THE BOTTOMLESS PIT.

of the church we have already described; then at the Devil's Chair, a gigantic crystallization in the form of a fauteuil, which is suspended, sparkling and shining, above the black jaws of a gulf known as the Bottomless Pit.

The spectacle, says M. Ernest Duvergier de Hauranne,

is surprising and terrible. Picture to yourself a horizontal gallery, abruptly interrupted ; sombre depth beneath your feet, sombre depth above your head. A wooden bridge spans the chasm. Conceive, if you can, the silence, the solitude, the choking sepulchral atmosphere, and your own shadow, phantom-like, bending over the abyss in the feeble glimmer of your lamps as they waver in the shadows.

More than one dreary legend is connected with the Bottomless Pit ; each guide has his own, and travellers, whose imaginations are easily touched by dramatic recitals, may take their choice at the cost of a little embarrassment.

We may put on record, however, a very sad adventure which took place some years ago in this dangerous locality, if we may trust the veracity of the American guides.

Two young lovers, separated by the inflexible will of their respective parents, instead of endeavouring to secure in secret the assistance of a clergyman, preferred to seek union in death, and flung themselves headlong into the chasm, bound to one another by a silken girdle : a letter, and the young maiden's handkerchief, which were found in the adjacent hall, explained their fatal resolution. The two families, desirous of paying the last tribute of affection to the poor misguided victims of an over-romantic attachment, offered a large reward to any one who would descend into the Bottomless Pit. A guide, slinging round his waist and under his arm-pits a stout knotted

rope, made the attempt ; but after being lowered to a depth of upwards of two hundred feet, he was so terrified and deafened by mysterious noises and a smell of sulphur, that he was forced to ascend precipitately.

We may also relate, on the faith of the guides, another adventure, affording a painful illustration of the horrors of that "domestic institution" which was once the reproach of the great American Republic.

Two fugitive slaves from a town of Alabama, on their way towards the Northern States and the joys of freedom, sought at night a temporary asylum in the Mammoth Caves, in the hope of remaining concealed for a sufficient time to throw their pursuers off the track. But it was not easy to elude or disconcert the man-hunters, assisted, as they were, in their diabolical work by the instinct of ferocious bloodhounds, trained specially to the pursuit of runaway negroes. So, soon after the unhappy maroons had concealed themselves in the remote recess, the pack following up their trail broke out, loud-mouthed, at the entrance to the cavern, and made known to their masters the presence of the wished-for prey.

Then commenced, in the thousand windings of the sombre labyrinth, a new kind of chase ; a hunt by torch-light, to which neither the shrill voice of the horns was wanting, nor the joyous shouts of the numerous planters of the neighbourhood, all of them proprietors or breeders of human cattle. The bitter pursuit lasted for a whole day. At length the two fugitives, pressed from corridor to corridor, and crypt to crypt, were hunted into the excavation which abuts on the Bottomless Pit. Then, know-

ing that behind them were chains and torture, and before them death, they did not hesitate. To the howls of the furious dogs, to the shouts of the purveyors of human flesh, they replied with a shriek of defiance. For a moment they were visible, by the glare of the torches flung in their direction, standing erect, hand clasped in hand, in the recess which opens on the awful gulf; then they flung themselves into its silence, and earth knew them no more!

The Bottomless Pit is not the only gulf of this kind which occurs in the Mammoth Caves. There exists, literally, a host of gigantic fissures, like wells, where the waters of old engulfed themselves beneath the surface, and poured their tribute into the subterranean reservoirs. The vaults of these wells are ogival, and their sides are wrought with pilasters, as if by a Cyclopean hand: when the visitor finds himself suspended there in space, he might well believe himself in the nave of some mighty cathedral, not less than three hundred feet in elevation.

In 1864, an Englishman, ambitious of immortalizing his name, resolved to explore the depth of one of these wells. He caused himself to be lowered by a rope, and succeeded in reaching the bottom, where he found a lake of living, moving water, with an impassable barrier rising around it on every side. "I am surprised," remarks M. Duvergier de Hauranne, "that the new Empedocles did not plunge into the gulf, and essay the original adventure of an aquatic expedition in this unexplored world."

Some distance further, and we arrive under the moth Dome, which is not less than 420 feet in height and covers an immense space with its vast cupola. impossible to see the summit, which is lost in the densest shadows.

We go a little further still, and come upon the marvellous scene in these magnificent caverns Chamber of Stars, or Starry Chamber.

"You reach it through a large gallery, whose ceiling vault is wrapped in shadow; the ancient bed of great river of the world of shadows. The walls are the heaven rises; you look above your head; you indeed the sky which sparkles yonder.

"Has the earth then opened? It is night: our promenade have lasted until evening? But mark two white walls, with their outline sharply cut against heaven; it looks like a desolate ravine, the dried-up of a torrent. I see the stars no longer; yet *there* ever, is the heaven of night, a calm, pure, and moon night, inspired by a soft blue lustre.

"You advance a step: look well: what ~~see~~ shining yonder like a star which sparkles and pears?

"See you not the white fleecy clouds skimming the surface of the firmament?

"How profound the silence! How motionless serene night!

"What, then, is yonder barren, voiceless, desolate region, in which Nature is wholly lost, except for light and vague murmur which accompanies her sleep

“You listen ; you hold your breath ; no, there is not a sound, not a whisper, not a warm and vivifying breath in that frozen air.



THE STARRY CHAMBER.

“You dare not speak ; you feel as if it were profanity to raise your voice.

“You think yourself on one of those dead and naked planets, where mineral nature reigns in the bosom of a

silent, terrible solitude ; on some earth never warmed by the sun, and which is animated by no kind of life." *

All this phantasmagoria is obtained by the reflections of light, skilfully projected by the guides on the roof of the cavern, which is of a different description of stone from the walls ; namely, of a black gypsum, with greenish tints, completely covered with sparkling crystallizations.

Now see before you Cleveland Avenue, whose sides seem tapestried with charming flowers of an exceeding delicacy. This resemblance occurs to the mind of even the most prosaic visitor.

The avenue opens on the Snow-Ballroom ; the brilliant incrustation which covers the walls is of a dazzling whiteness.

Roads alternately broad or narrow, smooth or rugged, level or steep, lead from this point to the Rocky Mountains, where the traveller must incessantly climb enormous masses of rock which have fallen from the roof.

Passing many an impending crag and gaping fissure which seem to presage other considerable landslips, we arrive at Fairy Grotto, where innumerable stalactites, ranged in immense colonnades, form a succession of elegant arches of a truly fairy-like aspect. Water percolates in all directions : in all directions fall the crystal drops whose musical chime echoes through the gloom.

At the bottom of the hall stands conspicuous a group like the crest of an immense palm ; the branches, gracefully drooping, seem sculptured out of a block of oriental alabaster ; from the summit of this graceful *ensemble*

* We have imitated this rhapsody from Duvergier de Hauranne.

leaps a fountain, the time-old product of all those calcareous deposits which glitter in the glare of the torches. The light, wandering in the voids left between these sedimentary formations, brings out their transparency. The delicate arches, ornamented with fantastically cut borders or mouldings, which spread above the traveller's head, remind him again of the beauties of Gothic architecture.

The Fairy Grotto, situated at one of the extremities of the Mammoth Caves, is distant about eight miles from the entrance.

We now arrive at the low level of the caves, to which a complete labyrinth of corridors, exceedingly rugged and exceedingly narrow, conduct us. One of these, being narrower than the others, has been significantly and picturesquely named, "Fat Man's Misery."

At Great Relief we raise our heads: then, continuing our descent, we traverse the chaotic scene of the Bandits' Cave; and finally arrive at the Dead Sea, a great internal lake in communication with the Styx. This small river, tranquilly following its course in the bowels of the earth, increases through the infiltration of the rains and interior basins of water, and flows onward, undoubtedly, to unite itself, by subterranean channels, with the Green River, which winds round the base of the mountain containing the caves.

We embark on board a boat, which awaits the arrival of visitors desirous of crossing to the other shore.

The Dead Sea is about two hundred feet broad, and,

in some places, thirty feet deep ; in its shallowest parts, where the surface is not disturbed, it is so transparent that the rocks in its bed are easily discernible, and the boat seems to float in the air.

No pencil can do justice to the play of light, the contrast of impressive shadows, which the gleam of the



THE RIVER STYX.

torches, reflected by the water, produces on the profound darkness.

After a thousand windings we arrive under a majestic elevated dome, where the voice resounds and, lingering, reverberates, like the strain of an organ through dim cathedral aisles.

Sometimes the Dead Sea overflows, and rises to a



THE DEAD SEA.

height of sixty feet ; sometimes even the whole gallery is entirely submerged.

At length we disembark ; to drag our weary feet along the muddy shore of the Infernal Lake, which reminds us of the description in Dante's *Inferno* :—

“The water was more sombre far than perse ;
And we, in company with the dusky waves,
Made entrance downward by a path uncouth.

A lake it forms, which has the name of Styx,
This tristful brooklet, when it has descended
Down to the foot of the malign gray shores....
Thus we went circling round the miry fen
A great arc 'twixt the dry bank and the pool "

Here and there croaks a solitary frog which has been borne into this gloomy region by the infiltrations of the Green River.

It is here the blind fish, indigenous to these caves, is caught. This singular animal is viviparous, and completely white; it has rudimentary eyes, but no optic nerve.

Crawfish, also blind, are found in the Styx.

Continuing our exploration, we come to the Maëlstrom, a gulf in which rats of a very curious species have been caught; rats as large as a rabbit, with gray back and white belly; as well as great yellow crickets, heavy and dumb, which leap not, nor do they sing, but drag themselves along like toads, and guide their course by their enormous antennæ; and also yellow black-spotted lizards, with staring, protuberant eyes. It is supposed there is some hidden opening near this point, through which the ancestors of these mysterious races made their way.

The Maëlstrom, of which we have just spoken, was explored for the first time a few years ago by an intrepid young adventurer of Louisville. M. Oscar Comettant has given, on the authority of an eye-witness, a pathetic narration of this frightful descent.

The proprietor of the Mammoth Caves, Mr. Proctor, had offered six hundred dollars to a guide named Stephen, well known for his intrepidity, if he would descend to the bottom of the gulf, and give an account of his perilous excursion. Notwithstanding the bait of

so large a sum—large for a man with no other resources than those of his moderately lucrative industry—Stephen refused.

But some years ago, a professor of Tennessee, a man as resolute as he was well-educated, undertook what no one before him had ven-



THE MÆLSTROM.

tured to undertake. He was occupied for some time in the necessary preparations. On the appointed day, he glided down into the abyss by means of a stout rope, and in this way accomplished about one hundred feet. But having arrived at this depth, feeling his senses wander, and a choking oppression on his chest, and an unconquer-

able dread take possession of him, he thought that he was going mad, and gave, in a panic of horror, the signal for drawing him up. When he reached the brink of the precipice he swooned ; afterwards, he acknowledged that he had felt so much fear, on touching the first ledge, that he would rather die than recommence the horrible journey.

Since that epoch, a considerable sum had been frequently offered to any person who would attempt the adventure. Some hardy fellows had essayed it, but none with any degree of success.

At length, a young man of Louisville, of a temperament completely inaccessible to fear, announced his intention of descending to the bottom of the abyss. Having persisted in his resolution, notwithstanding all the representations which were made to him, he made every preparation for the descent. He sent to Nashville for a rope of adequate length and thickness, and betook himself to the point of exploration ; that is, to the gulf situated about nine miles from the mouth of the caves.

And, first, he and his attendants fastened a heavy stone to the end of the rope, and lowered it gradually until it touched the bottom ; an operation which occupied some time. They were careful to dash the stone as violently as possible against the sides of the chasm, so as to detach all loosened and quivering crags, whose fall might otherwise more or less seriously wound the traveller in his gloomy excursion. Several masses of rock fell headlong. The reverberation of the noise of their fall rose to the mouth of the chasm, with a roll and roar like that of thunder. At the sinister din the attendants trembled ; the intrepid young man alone preserved his calmness, not evidencing emotion by the slightest contraction of the muscles of his countenance.

After wrapping round his head a kind of turban as a defence against falling stones, and providing himself with a lighted lantern, the young hero fastened the rope round his body, and gave the signal of descent. It was made slowly, to avoid accident ; and yet fragments of rock and portions of soil fell around the adventurer. Fortunately, they did not hit him.

While descending, the young man waved his lantern round about him.

At thirty feet below the brink, he discerned a ledge or platform,

from which, to judge by appearances, two or three galleries radiated in different directions. Then he gave the signal to halt ; noted on his tablets the existence of these galleries ; and ordered the attendants to resume lowering the rope.

At one hundred feet he stopped anew : he had discovered a spring of water, which issued from one of the sides of the gulf, and fell into the abyss with an ominous clang. This fact being ascertained, and recorded, the descent was renewed.

From this point the water of the cascade, scattering abroad in a fine rain, rendered almost useless the light of the lantern. The air grew difficult of respiration. The hardy explorer, wet through, and labouring for breath, did not the less strenuously persevere. Already the rope indicated a depth of one hundred and fifty feet, when suddenly a hoarse sound was heard, which struck terror to the hearts of the attendants gathered on the brink of the gulf. Instinctively the rope was tightened ; but the young man immediately gave the signal to continue the descent. The noise was produced by the fall of an enormous mass of rock, which, in its headlong way to the bottom of the chasm, had nearly crushed the daring adventurer, nor did he escape without some severe contusions.

A few feet lower, and he ascertained that the waterfall took an almost horizontal direction ; he heard it roaring, no longer beneath him, but by his side. Wiping the glasses of his lantern, on which the spray no longer fell, he obtained sufficient light to distinguish the objects immediately around him. Meanwhile, as the attendants kept lowering the rope, and the young man made no movement, one of the witnesses of this frightful descent, Dr. Wright, ordered them to stop, that they might assure themselves no accident had happened to him.

Nothing stirred.

"Haul up at once !" cried the doctor ; "haul up at once !"

Fearing the young adventurer had been suffocated, or had fainted from terror or want of air, they pulled lustily at the rope. But almost immediately, the young hero, who understood what was going on above, and who had resolved on touching, as he had promised, the bottom of the abyss, gave vigorously and repeatedly the signal of descent.

A sigh of satisfaction escaped from every breast. Those who held

the rope obeyed, and the explorer soon reached the bottom. He had traversed, in the entrails of the earth, in water, and in obscurity, lacking wholesome air, and incurring great risk from the stones which rattled like hail around him, above his head, and beneath his feet, the distance of one hundred and ninety-nine feet.

He ascertained that the bottom of the Mælstrom is circular, and that it measures eighteen feet in diameter. A small opening gave access to another cavity of inconsiderable extent. Our hero penetrated into it, and brought away some remarkably fine specimens of black silica, as well as several fragments of stalactite, not less white than the purest crystal.

Soon afterwards he signalled to be hauled up to a certain height, his intention being to explore the galleries which he had already discovered.

Having reached the mouth of one of them, that he might investigate it in its entire extent, he loosened from his waist the rope which had suspended him in space, contenting himself with holding the end in his hand. This was a most imprudent proceeding, as the event only too surely proved. Owing to the effort he made to launch himself into the interior of the shaft—leaping, with feet close together, a crevasse of some width—the rope slipped from him. It was death, if he did not succeed in regaining it—death by cold and death from hunger in that horrible tomb! Any other than this heroic youth would have died of fear; but, losing nothing of his coolness, he made a kind of hook out of the ring of his lantern, using his teeth as a tool, and then, planting his foot on a projecting stone, he extended his arm, reached the loosely-floating rope, and succeeded in bringing it towards him. This time he took care to fasten it firmly to the rock, and then he resumed his exploration, as if he had not just escaped the most frightful peril! He did not stop until his passage was obstructed by a landslip. At length, shivering with cold, exhausted with fatigue, he returned to the mouth of the excavation, and having twisted the rope round his waist, gave the signal of return.

The operation was not accomplished without difficulty, on account of the mal-arrangement of the knotted rope round the body of the explorer, which caused him cruel suffering. But this sensation soon disappeared before the imminence of a new peril, which,

however, was not brought about by any act of the young hero himself.

He had arrived within ninety feet of the brink of the Mælstrom, when he suddenly heard shouts and cries of terror above his head, and, notwithstanding the distance, could distinguish these words : "The rope is on fire ! water ! water !"

And in fact the friction of the rope against the long plank, which served as its support, had ignited it, and, as there was no water at hand, they expected every moment to see the unfortunate young man fall into the yawning abyss beneath his feet. Happily one of the assistants had about him a flask of brandy and water. He emptied it on the burning rope ; and at length, without other accident, the explorer reached the mouth of the Mælstrom, as calm as he was when he took his departure. Dr. Wright felt his pulse, and found it beating quite equably and regularly.

The eye-witnesses of the adventure were much more moved than he who had been their hero, and who had so nearly fallen a victim to his daring ; for now all the danger was over, they stretched themselves upon the ground, spent with fatigue and emotion.

The young man dressed himself in the warm clothing which had been provided for him, drank a small glass of rum, and then related every particular of his excursion, of all whose dangers no one had formed an idea.

The narrative ended, it was discovered that while listening to it Dr. Wright had fainted.

The bold explorer had scratched his name on a rocky projection in the very deepest part of the abyss.

We now return to the Dead Sea.

It is here, and at the river Styx, that visitors generally halt ; not, indeed, that they have reached the limit of the excavations, for these extend in other directions even to unknown limits. A traveller, who penetrated five leagues beyond the Dead Sea, assured himself, in spite of the impossibility of pushing forward, that the caverns were really prolonged much further.

However this may be, as many as two hundred and twenty-six avenues have been counted in these immense excavations, fifty-seven domes, eleven lakes, seven rivers, eight cataracts, and thirty-two pits, or rather abysses, some of which are of an extraordinary depth and diameter.

The exit from the caves is three leagues distant from the entrance. We reach it after forcing our way through a low and narrow gallery, in which we are almost forced to crawl.

It is with no ordinary satisfaction that we see once more the light of day after our long and wearisome subterranean trajet.

For six hours, says M. Duvergier de Hauranne, we wandered in these caverns : at length, behold ! a yellow ray glided through a crevice ; the sides of the rock began to shine like gold, then like a mass of dazzling snow, immediately in front of us. Verdure, rock, greensward, —all threw off a brilliant and supernatural radiance. Half blind, I stumbled and tottered ; the earth which I trod sent up a myriad sparks ; a thousand joyous noises deafened me. How warm and soft the air ! How resplendent the azure of the firmament ! How delightful the songs of the birds, the chirrup of the grasshoppers, the glorious rays of the sun flooding the open country with radiance ! I cannot describe to you the joy, and rapture, and confusion of the first few minutes ; it seemed to me as if I lived again, and had started from a tomb.

Such are the Mammoth Caves of Kentucky, according to the testimony of credible witnesses.

THE ALABASTER CAVERN OF CALIFORNIA.

The province of El Dorado, on the Californian coast, can also boast of a marvellously beautiful stalactitic grotto. It is situated on the flank of a mountain of marble-like appearance, which strikes across the valley of El Dorado.

Its discovery was accidental. A wealthy settler, Mr. William Gwinn, had instructed his men to quarry among the stone for material with which to build a furnace. In the course of their operations they came upon this cavern.

We go on, he says, from astonishment to astonishment. Yesterday, while quarrying, we made an opening of about fifteen feet in the midst of a space of about one hundred feet by thirty. It resembled a magnificent pulpit, such as one sees in our cathedrals and churches; and the area we had discovered might well be taken for the sanctuary—the Holy of Holies. The beauty of the scene is completed by a splendid drapery of alabaster of every tint, from white to rose-red, which hangs suspended above the spectator. Immediately near the pulpit shines a lake, which extends to some unknown distance. All this we saw; but to our great admiration, on arriving in the centre of the first chamber, we discovered the entrance to another and still more magnificent one, two hundred feet by one hundred, with a roof of the finest alabaster, reproducing various forms of drapery.

The grandeur of the spectacle produces a vivid impression on the mind: a power is before us which defies ruin; an antiquity which history cannot pretend to cal-

culate ; a beauty which every day enhances with some new charm ; a source, utterly inexhaustible, of the highest and purest enjoyment.

As soon as this discovery was made known, visitors flowed into the grotto in such streams that, to protect its wonders from the barbarism of a vulgar curiosity, its owner was compelled to close it for a time, while making such internal arrangements as should enable every person to see freely, but not to destroy.

The cavern opens off the main road which traverses the valley. We descend three or four steps, to find ourselves in front of a door which is carefully kept closed when there are no visitors in the grotto.

Crossing the threshold, we enter the first chamber, measuring thirty-six feet in length by seventeen in breadth, and varying in height from five to twelve feet. It is a very curious apartment, though the walls are perfectly smooth. The roof is ornamented with beautiful stalactites, bearing a close resemblance to gelatinous mosses or a very delicate coral, and with long pendent icicles which seem made of alabaster. This splendid excavation is sometimes named the Coral Grotto, and sometimes the Alabaster.

Next comes a passage, at whose extremity we find another chamber, with a gently sloping roof, covered thickly with concretions, some of which are exactly like coral, while others resemble clumps of Iceland or club moss.

Then we arrive at the Cave of Enchantment.

This is a large and strangely-shaped chamber, about

one hundred and thirty feet long by fifty feet broad, and from four to thirty feet high. Dazzling stalactites, again of a coralline character, droop in irregular columns, and exhibit an almost infinite variety of forms, with tints which vary from the purest white to a rich chocolate-brown. Their colours admirably contrast with the gloomy vaults of the hall.

Descending to the left, our attention is attracted by other groups of stalactites of the most beautiful aspect. Some may be compared to slender tubes, from two to five feet in length ; three or four may measure upwards of eight feet. Unfortunately, the first visitors admitted into the grotto had the barbarity to destroy or shatter several. Others may be likened to elephants' ears ; and others again to thin and reverted cones. On examining more closely these and other groups of stalactites, we notice at their base numerous projections of singular beauty. Here, says Hutchings, you would think you were looking at petrified mosses of admirable brilliancy and transparency ; there, at a pretty mushroom, garnished with diamonds ; yonder, at a forest of pines, which, to accommodate themselves to circumstances, have thrust their crest downwards ; elsewhere, at flakes of the finest merino wool or smoothest silk.

We now turn to the right, ascend a flight of steps, and arrive at the most magnificent part of the cavern. Before us rises a tall stalagmite of singularly fantastic aspect, four feet eight inches in height, and three feet one inch in circumference at the base. It is known by various names,—such as Hercules' Club, or Lot's Wife.

A little further, above a small hillock which resembles a mass of frozen snow, is a tolerably narrow opening, through which the eye plunges into a cavern of immense depth, its roof incrustated with coral-like petrifications, its walls hung with drapery of jet. In the solitude hangs suspended an immense concretion which has all the appearance of an enormous heart—the heart of a giant.

Along the sides runs an elevated and nearly horizontal platform, where seats and a table have been provided for the accommodation of a small orchestra and a select public. We were charmed beyond measure, says Hutchings, at hearing some distinguished virtuosos play several symphonies of the great masters,—of Mozart, Haydn, and Mendelssohn. Some Æolian harps, hanging from the roof, sent from chamber to chamber echoes of a delicious harmony.

Following these vast chambers are other and smaller ones, whose ceilings are embellished with concretions resembling jets of water suddenly arrested in their course, and frozen.

Then, advancing along a defile, we reach the most splendid chamber in the grotto, the Crystal Chapel.

Impossible is it to find language or comparisons worthily to describe its magnificence. The sublime grandeur of the imposing spectacle fills the soul with a surprise and wonder which make the spectator dumb.

When the mind, recovering from its first impression, is able to examine the gorgeous spectacle in detail, we perceive a roof or ceiling completely covered with thousands of what seem to be gems and icicles of incomparable

brilliancy. At intervals we see large squares, or panels, whose mouldings seem formed of diamonds; while the panels themselves resemble glass windows incrustated with frost in rigorous winters. Mosses, corals, silken and woollen fleeces, trees, and numerous other graceful ornaments, fill up the spaces between the stalactites. In another direction a huge pile of rocks, resembling a mass of icicles, confronts us. It appears to have been gradually formed by successive deposits. Some of the rocks are attached to the overhanging roof by all kinds of columns. These *reliefs*, these decorations, are of different colours; but the predominant tint is a rosy white. At the bottom of the chamber we see the entrance by which we penetrate into it. To the right is a large stalagmite, whose summit is crowned with a kind of dome, and embellished with a variety of very beautiful undulating folds. You might suppose it to be a drapery arranged with inimitable elegance, and wrought in alabaster by the great Architect of the universe.

There are several other chambers well worthy of a visit—as, for instance, that which is called the Picture Gallery; but it is unnecessary to describe them, as they bear a close resemblance to those already examined.

The conclusion at which every visitor arrives is one which, we think, our readers will find no difficulty in accepting—that of all the wonders of the Californian wonder-land, the most remarkable, and assuredly the most interesting, is the Alabaster Cavern.

GROTTOES AND CAVERNS WITH CONCRETIONS OTHER
THAN CALCAREOUS.

Certain grottoes and caverns there are which contain deposits and concretions of a different character from the stalactites and stalagmites hitherto described.

Thus, the strata of which the Alps are composed are filled, in many places, with grottoes, whence the Swiss obtain the substance known as *rock-crystal*. These cavities are discovered, when no fissures or openings exist, by striking the rock with an iron hammer. If it gives forth a hollow sound, a grotto lies underneath. But a still surer indication is a vein or zone of white quartz, intersecting the rock in different directions. It is harder than the rest of the rock, and the inhabitants of Switzerland name it the *band*, or *ribbon*. Another sign by which the presence of rock-crystal is detected is, when water oozes from the rock near any place where either of the previous indications has been observed. If all these are found in conjunction, the mountain may be opened with every probability of success, whether by pickaxe and hammer, or by charges of powder; and afterward a passage is excavated, resembling the usual miners' gallery. It has been observed that water is always found in these grottoes. It accumulates at the bottom, after falling drop by drop from the upper parts. It would be interesting to study the formation of stones and crystals by examining attentively the manner in which Nature operates in these strange subterranean laboratories, and analyzing, by the proper chemical ~~processes~~, the waters

they contain, and to which are due all the phenomena they present.

To our previous remarks upon calcareous concretions, we may add, that it would be wrong to attribute all of them exclusively to the waters of infiltration. It is very probable that true calcareous springs may, in certain cases, have assisted in the formation of the stalagmitic tabular beds, often of considerable density, which cover the soil of numerous grottoes, and fill up their fissures and crevices.

ICE-CAVES AND NATURAL GLACIERS.

NATURAL GLACIER OF THE ABBEY OF GRACE-DIEU, IN THE DEPARTMENT OF THE DOUBS, FRANCE.

In the Jura, and in other mountain-chains, numerous examples may be cited of natural glaciers hidden in the depths of profound caverns. The formation of the ice would appear to result from the interior circulation of an excessive cold ; but upon this point our scientific authorities are not in agreement.

One of the most remarkable illustrations of this natural phenomenon is the Natural Glacier of the Grace-Dieu ; a very curious cavern, situated in the heart of an ancient forest, in the territory of Chaux-lès-Passavant, not far from Baume-les-Dames, and five or six leagues distant from Besançon.

Its name is derived from the old and celebrated Abbey of Grace-Dieu, which lies close at hand, and is situated at the extremity of a deep, winding gorge, threading

among the calcareous rocks of the chain of the Jura, so rich in caverns of every description.

There is space in this narrow defile only for a brook—which descends with a gentle flow—and for the roadway which now leads to the forges. When you think yourself astray among woods and savage rocks, you come unexpectedly upon habitations and men. But these lofty walls are no longer tenanted by cowed monks ; it is not for matins or vespers, or for out-door labours in the sunny fields, that the monastery bell now rings. The great buildings which now confront us are covered with moss and black with smoke ; the foaming waters which come down from the mountains are utilized as the motive power of busy factories ; the sounds which fill the echoes are the din and whirl of restless machinery, the monotonous murmur of revolving wheels, and the strident clang of the flames escaping from the furnaces. In the rear of the iron-works the valley is prolonged for a short distance, until it terminates abruptly at the foot of one of those large and lofty weirs or dams which seem to have served both as a passage and a barrier for the rushing water-courses, when our continent was torn asunder by agitated seas. It is from the summit of this dam, or natural weir, that the torrent which, lower down, bathes the valley, rolls, and falls, and breaks into foam and spray. We reach the height of the cascade by climbing on the left a pathway excavated in the rock, and from thence the gaze plunges almost vertically to the bottom of the ravine. The glacier is close at hand, and on all sides overshadowed by an ancient forest which protects it from the rays of the sun.

The glacier of the Abbey of Grace-Dieu seems to have been known ages ago. In 1636 it afforded an asylum to the inhabitants of the surrounding country, and enabled them to escape the soldiers of the Duke of Weimar, who ravaged the land with fire and sword. The first description of it which has been put on record dates from 1712; it was published in the *Mémoires de l'Académie Royale des Sciences*. In 1731 the Marquis de Croismare wrote on the spot a very scientific and accurate account. Another, dated 1743, may be found in the first volume



ENTRANCE TO THE ICE-CAVE OF GRACE-DIEU.

of the *Mémoires des Savants Étrangers*, printed by order of the Academy. It is scarcely necessary to add, that since this last-named date every author who has described the numerous natural curiosities of Franche-Comté has given a foremost place to this fine glacier.

The entrance of the grotto, sixty feet broad and about eighty feet high, is ornamented with double strata of

horizontal rock-work, forming above the opening two kinds of cornices or mouldings, cut almost square, of which the loftier and the more advanced is surmounted by a vertical mass of grayish stone.

Formerly the entrance to the glacier was not closed, and all the inhabitants of the country removed the ice as quickly as it was formed, for their own private advantage. A summer camp, stationed at St. Jean de l'Osne in 1724, made great havoc in this magnificent grotto. Happily, an intendant of Franche-Comté, whose name should be held in respect by all lovers of the sublime and beautiful in Nature, M. de Vanom, ordered the entrance to be closed with a wall twenty feet in height, in which a small door was opened, whose key was entrusted to the village authorities, with instructions to prevent the removal of the ice.

The visitor enters the cavern by a broad, abrupt, and stony descent, which is relieved at first, but only for a short distance, by some traces of vegetation.

The grotto soon enlarges to assume the figure of an irregular oval, so disposed that the entrance marks one extremity of its major diameter. This oval encloses a kind of cabinet, about forty feet broad by fifty-five feet long.

In the first section the rock all around rises vertically, like a wall, to the height of about thirty-two feet, and supports a vault which is raised to an elevation of eighty to ninety feet; the lateral rock is tolerably smooth, and composed of layers of stone, parallel but unequal, of a colour bordering upon green. The vault, though its surface is rough and rugged, presents to the eye, however, a very agreeable curve: on the right we see a long,

narrow, deep fissure, which, however, lets in no light; the edges are ornamented with festoons of ice, and drops of water fall from them continuously, to collect in the bottom of the cavern, and eventually form a huge flooring of ice, about forty feet in diameter. To the left, as we enter, we see a similar mass of ice, but of smaller dimensions, the water not falling so abundantly, and oozing from the roof only through almost imperceptible chinks and fissures. These two piles of ice were formerly of a great elevation, and mounted to the roof of the cavern in huge pillars; but it appears that the supply of ice at Besançon failing in 1727, these pillars were destroyed, to the great profit of the inhabitants of the town and the serious injury of the picturesque.



INTERIOR OF THE ICE-CAVE OF GRACEDIEU.

As we descend into the ice-cave, great white masses become more and more resplendent; they form colossal stalactites, which reach even to the ground, and might be mistaken for columns of silver supporting the roof of an immense and gloomy edifice. Against the walls hang broad, bristling sheets of icicles, which in some places resemble solid cascades. In a word, we meet with all the variety of forms which in the calcareous grottoes we see rendered in alabaster, but here possessing a white-

ness and a splendour tempered only by the obscurity of the place.

The soil or bed of the cavern consists of a tolerably smooth rock, completely covered by a stratum of ice of varying thickness. This frozen platform fills up the entire area described by the oval of the grotto, and terminates at the opening of the furthest recess, where it rises with a slope of six to seven feet. The interior of the grotto forms a vault, excavated in a stone of so much beauty—partly of a clear reddish-brown, and partly of a pale blue—that it seems one single mass of rock; and you could fancy yourself standing before the remains of an antique and much-worn sculpture intersected by vermiculated bands. Above, a small cranny is discernible, whence constantly descending drops of water gradually form a platform of ice resembling those already described.

It has been remarked that in winter a portion of the ice melts, while in summer, on the contrary, considerable quantities are regelated. A credible observer, who affirms that he visited the cavern once every ten days for several successive years, has ascertained the truth of this assertion. At the beginning of July he found in a certain spot a lump of ice weighing between fifteen and twenty pounds; but in the middle of August he found there a large number of lumps, each sufficiently large to load a cart.

In winter, also, a very thick fog issues from the ice-cave, and conceals it from the view. This mist is never entirely dissipated before the month of July.

The ice which forms in the cavern is sensibly harder

than that of the rivers ; it has fewer air-bubbles, and does not thaw so readily.

A pistol discharged in the cavern makes a considerable report ; but any person desirous of making the experiment must take care not to expose himself to the fall of the ice attached to the roof of the grotto, like icicles suspended from the eaves of houses in winter.

The pleasure we experience in admiring the marvels of this beautiful cavern is somewhat moderated, one must own, by the excessive cold which one undergoes. The temperature, perceptibly lower at the very entrance, continues to sink as we penetrate deeper, and at length the cold is almost unendurable. It is with considerable satisfaction, therefore, we return to the beneficent warmth of the sunshine. Earth's flowers and verdure, and the blue brightness of the cloudless firmament, seem then more marvellous than they have ever seemed before. The contrast of the cavern in which we were surrounded by rime and frost, in which we breathed the frozen air of winter, with the soft atmosphere of the valley, loaded with balm and perfume, is most delicious.

THE ICE-CAVE OF VERGY.

The Ice-Cave of Vergy is situated in the valley of Reposoir, not far from Cluses.

We borrow from a paper by M. Thury, a professor in the Académie of Geneva, the following narrative of a visit which he paid to it in 1861, accompanied by some of his scientific brethren :—

“ We set out from Geneva for Cluses,” he says, “ on the 18th of January 1861.

"At the confluence of the valley of the Reposoir with the great valley of the Arve, and about two leagues on this side of Cluses, lies the village of Scionzier, the key of the Reposoir valley. There we engaged as our guide a shoemaker well acquainted with the road to the Glacière de Vergy. We spent the night at the convent of La Chartreuse, situated about half-way up the valley, in a landscape of severe beauty.

"From the monastery we descend by a steep path, a quarter of a league in length, to the village of Pralong du Reposoir. Having halted for awhile to arrange our baggage, we put some questions to the mountaineers. They all agreed in asserting that we should find no ice in the 'great cave of Montarquy' (as they call the grotto), but water only, and a warm atmosphere. Yet, to our questions,— 'Have you been there? Do you know any person who has visited the grotto in winter?' the not less unanimous answer always was,— 'In winter it is not a safe excursion. No one goes there in winter.'

"The weather was magnificent. We clomb the slopes of snow without any serious difficulty. The last few yards alone were somewhat difficult, on account of the partial liquefaction of the snow, and the acceleration of our pulses, which marked 120 to 140 beats per minute.

"It was exceedingly warm. The thermometer, in the sun, indicated 70° F., and we were compelled to rest a few minutes before penetrating into the grotto. It was then noon. We passed into a vast chamber, from 130 to 200 feet in depth, the soil of which, strewn with fragments of rock, inclined towards the extremity, and also towards one of the sides. We saw ice of exceeding dryness accumulated in the form of stalactites, stalagmites, columns, platforms, and inclined planes. Nowhere could we see any water; the atmosphere was motionless and cold.

"At some distance from the mouth of the grotto, on the right-hand side, and level with the soil, we noticed an opening which led into a circular cavity, the so-called 'chapel,' about twelve to fourteen feet in diameter. At the bottom of this cavity was a fissure in the rock.

"All the cavern is excavated out of the solid rock, which is a yellowish limestone. There are two floorings, or platforms: one

INTERIOR OF THE ICE-CAVE OF VESGY.



large, and one small. The ice of both we found transparent, smooth, and dry. Fifteen great stalactites, and many small ones, drooped from the roof. From the soil rose, to the height of four and five feet, numerous conical, claviform, fusiform, paraboloidal stalagmites—some shaped like a long-necked bottle or reverted top; others like a bladder, or like several bladders placed one upon another: some ramified, and some simple; others with a very slender, or with a broad and elongated, base.

“Among the columns or pilasters of ice, attached by both extremities, one is particularly remarkable. It is situated near the inner angle of the great platform, and close to the further side. About thirteen feet in height, connected by its base with the frozen floor and by its summit with the rocky ceiling, it consists of a peculiar, perfectly dry, homogeneous, and translucent ice, whose appearance can be compared only to that of the finest porcelain.

“In this grotto, as in other ice-caves, the formation of the ice necessarily takes place at that season of the year when both extreme cold and great humidity prevail—that is, in the autumn, and more particularly in the spring, when the snow first thaws. From this point of view, therefore, we see that it is accurate enough to assert that ice does not form in winter.

“At half-past four we quitted the ice-cave. The descent offered no difficulty. The heavens were beautiful with those elementary and vivid tints which are wholly unknown to the dweller in the plains: in the east, a sombre rose and apple-green, melting into a lustrous metallic brown on the western horizon.

“We halted at the first village. When our guide, in reply to inquiries about what he had seen in the ‘great cave,’ affirmed that it was full of ice, and that its atmosphere was cold, a mountaineer exclaimed, after a moment’s silence,—‘That may be; but in the true ice-caves there is no ice in winter!’”

It is just this popular and generally accurate observation which gives so much interest to the discussions of scientific men. What is the function of the air-currents? What is that of the refrigeration of the air by its saturation with aqueous vapour? So far as relates to the ice-

Caverns, says Thury, the most urgent matter is to collect facts. As yet they are not sufficiently numerous to justify us in founding a theory upon them.

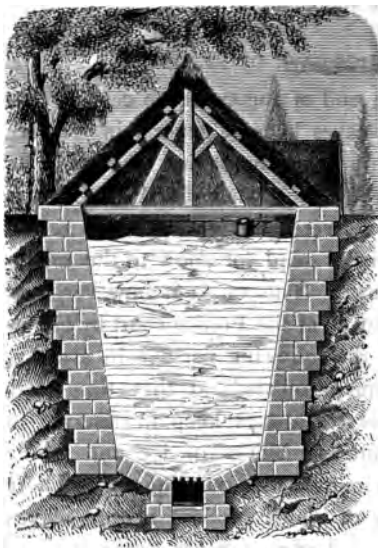
ARTIFICIAL ICE-CAVE OF ST. OUVEN.

It was not until the end of the sixteenth century that the use of ice and ice-caves became general in Western Europe. The French who accompanied Francis I. to Nice, on the occasion of his interview with Paul III. and the Emperor Charles V., were greatly surprised at seeing the Italians and Spaniards send for snow to the mountains to cool their wines. This custom, however, was soon afterwards introduced at the French court by Henry III., which suggested the following passage in a satire, "The Island of Hermaphrodites," at that time very popular:—"In summer we always keep in reserve, in suitable localities, immense blocks of ice and whole mountains of snow to mingle with our liquors." These are the first ice-caves of which modern history makes any mention. In the following century the use of ice had so widely extended, and its sale had become so lucrative, that a company of speculators sought and obtained a monopoly of the trade. Its price then rose to an enormous figure, and the government was forced to interfere and open up the commerce.

The ice-wells now most generally adopted are little other than large cellars, placed under certain special conditions, in which is stored up during the winter a supply of ice collected from the natural or artificial reservoirs in the neighbourhood. These cellars, whose entrance should always face the north, are surrounded by

straw and roofed with thatch, for the purpose of intercepting the heat. Moreover, their arrangement should be

such that a slight evaporation may take place freely, and maintain a constant freshness.



ARTIFICIAL ICE-CELLAR.

The immense ice-cave situated in the centre of the plain between St. Denis and St. Ouen, has been constructed, however, on different principles. It is designed to produce artificially a great quantity of ice, as well as to provide storage-room for the

ice brought from the reservoirs in the neighbourhood of Paris.

The method adopted in the construction of this huge ice-cellar is that in vogue in Bengal, where the heat of the climate renders the production of ice very difficult, while, at the same time, it makes its use exceedingly desirable. Let us briefly describe the process and the mode of its application in Bengal. The natives manufacture a number of large, flat basins of earthenware, like large dishes or plates; into each is poured a quantity of

water, then they are isolated at a certain elevation above the ground, on a basis of dry straw, in the middle of the plain. The water in these basins receives no heat from the plain, because it is separated from it by non-conducting bodies, while, on the other hand, its own heat radiates freely towards the "celestial spaces," which, being very cold, do not return it any warmth in exchange; the water, therefore, grows colder and colder, and in the morning is found condensed into ice.

This system has been applied on a large scale by M. Lenoir, in the Ice-Cave of St. Ouen. The water, forced by powerful pumps into a succession of lofty tanks, descends from their highest level in excessively feeble sheets and scattered cascades; cools by evaporation and by contact with the air during this descent; and then is received into immense timber reservoirs, several hundred feet in length, and upwards of three feet and a quarter above the ground: it flows here very slowly, forms a mere shallow stratum or sheet of water, and finally congeals. When, through the superimposition of several strata, one upon another, it has acquired a sufficient thickness, workmen break it up into portable blocks, and remove it to the great ice-cellar close at hand.

Probably, this same ice-cellar is the largest in the world. It consists of an enormous circular well, fenced off from the soil by a double inclosure of masonry, and consequently by a sufficiently thick stratum of ice, whose tranquillity nothing can disturb. The roof, constructed of solid timber, and surmounted by a hut in which are placed the pumps intended to exhaust the waters of

fusion, is of such a density as effectually to prevent the admission of heat.

This well, or cellar, is about one hundred and ten feet in diameter, and upwards of thirty-five feet in depth. It will hold fully fifteen thousand tons of ice.

The carts used for the transport of ice in summer are so many ambulatory ice-caves, each with a roof of straw.

We may add that M. Lenoir's process has proved completely successful, and that it turns out considerable masses of ice even on balmy summer mornings when the temperature is many degrees above zero. This ice, however, is denser, as well as purer, than that obtained from natural sources.

The immense ice-cellars of Chelsea are constructed upon a system which is entirely new in Europe, though it has been long in vogue in America and India.

They consist of four large magazines, in which the air circulates freely; and each will contain about a thousand tons of ice, or 40,000 cubic feet.

To prevent the intrusion of the external atmosphere, they are lined internally with a double wall of brick and a wall of solid timber. Between the brick and the timber a thick layer of saw-dust closes every chink and crevice against the outside air. These ice-cellars contribute largely towards the annual supply of the London markets.

In a book which professes to treat of the wonders of Nature beneath the surface, this chapter on artificial caves may be regarded as a digression. We trust, however, it will not be found uninteresting.

BONE-CAVES.

In excavating the soil of the caverns and grottoes of the earth, and especially of the more remote and sequestered, we frequently come upon a prodigious quantity of bones, of shattered craniums and dislocated jaws, mingled with mud, sand, and pebbles. Now it has been recognized that these were the bones of a multitude of animals which must have been much astonished, not only to find themselves in these abysses, but in such heterogeneous company : rhinoceros, elephant, lion, tiger, stag, wild boar, hyena, bear, horse, squirrel, hare, and even birds. Are we then to admit that in the primeval world all these animals, so different in nature and habits, lived side by side, in a more than Arcadian simplicity, more especially when the climatic conditions, in all probability, were not the same at that remote epoch as they are to-day ?

As for the question, How did the bones of these animals come to be buried together, and in such numbers, in the caverns ? we may propound several answers.

Though geologists are not in accord upon this point, the balance of authority inclines to a belief that most of the fossils discovered in the mud of the caverns were carried thither by water-courses, either periodic, or of a torrent-like character.

We may add that the habits of certain mammals are singularly well adapted, in some circumstances, to favour such an interment. The hyena, for example, whose habits are well known, is not only accustomed to dwell in caves for a time, but also to carry thither its prey.

The bear, and other animals akin to it in race, are known to spend a portion of their existence in subterranean retreats. The insectivora, and some of the fossorial carnivora, the hybernating rodents, and others which live temporarily or periodically "beneath the surface," may well have been surprised in their asylums by subterranean currents, and carried into deeper and vaster excavations, to lie embedded in drift, which would contribute to preserve from destruction their little and delicate skeletons.

Other circumstances, as M. Desnoyers remarks, may well have occurred upon the ancient continents, since they occur at the present day. Animals may have sought in the caverns a temporary asylum during occasional inundations, and have been engulfed, owing to the very expedient they adopted for security. Frequently the herbivorous and ruminating animals, and others, will have fallen into, and have perished in, the gulfs and numerous crevasses which would intersect their track, and their remains have been cemented by calcareous concretions, as seems to have happened most often with the so-called *osseous breccias*.

All these different causes seem often to have acted in combination, and to have wrought, either isolatedly or successively, in certain grottoes.

We may mention another cause, quite historical and modern, to which, in certain localities, the traditions of the people relate, but which can have occurred only rarely, and in absolutely exceptional circumstances—namely, the interment of animals through the act of man, either during the prevalence of epidemics, or under the

influence of religious creeds and usages. The testimony of an ancient and trustworthy authority, Ælian, may here be cited :—

“ Among the Indians of Asia,” he says, “ exists a grotto consecrated to Pluto, in whose depths are unknown cavities, and immense subterranean galleries never traversed by men. How so profound a gulf was formed, the Indians do not explain, and I shall not weary myself by attempting to discover. Thither the Indians annually conduct upwards of three thousand different animals—sheep, goats, bulls, horses—seeking in this way to divert, each according to his resources, the effects of some panic terror, or of the encounter of some ill-omened bird. They precipitate the victims into the abyss. These, under the influence of some mysterious charms, allow themselves to be easily guided to the fatal spot, and, arriving on the brink of the chasm, leap into it without reluctance ; (!) but after they have fallen into its immense and obscure profundities, they are never seen again. Only the listener may hear the bellowing of the oxen, the bleating of the sheep, the voice of the goats, the neighing of the horses ; and if you approach the ear of these caverns, the same sounds you may detect for a considerable period. Nor do they cease to be reproduced, for every day the Indians offer up additional animals. But whether it is the victims newly sacrificed, or the older ones, which one hears, I cannot pretend to determine.”

Assuredly, however, as Desnoyers hints, it is not probable that this particular mode of animal interment was very general. But we have thought it useful to introduce the reference, were it only to put the reader on his guard against all over-exclusive and dogmatical explanations of a natural phenomenon so complicated as the concealment, “ beneath the surface,” and in caverns and grottoes, of so large a number of widely different animal species.

We shall not attempt to speak here of *all* the caverns in which fossil and other relics have been found. They

are very numerous, and occur not only in every European country, but also in Asia, Africa, and America. We shall confine ourselves to passing successively and rapidly in review the most remarkable bone-caves of the four countries in which they are most numerous and most interesting : England, France, Belgium, Germany.

BONE-CAVES OF ENGLAND.

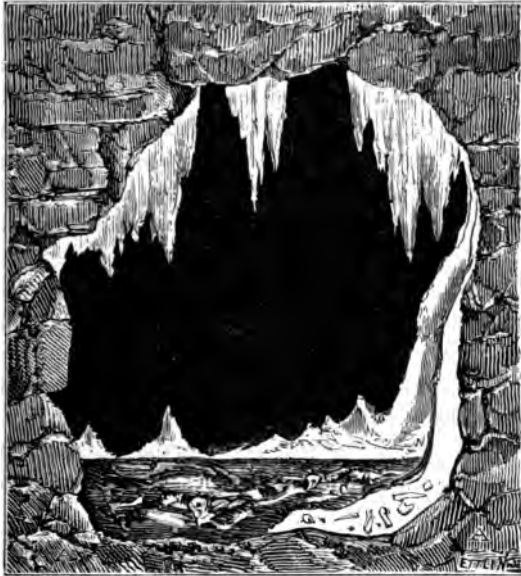
It was in England, and in the celebrated Kirkdale Cave, that attention was called, for the first time, to the fact, apparently so extraordinary, that the bones of animals of different genera were buried together in the grottoes.

The Kirkdale Cave is situated in Yorkshire. It is excavated in the Jurassic limestone, and covers a very considerable area with its long and narrow tunnels, none of which attain to any considerable elevation.

In its recesses has been found an almost incredible quantity of fossil bones, belonging to a great number of different animals. The bones of hyenas, however, predominate ; and Dr. Buckland, the eminent geologist, discovered the remains of as many as two to three hundred individuals of this species. Scattered in the clay-bed, he also found the fossil excrements of that fierce carnivore, and the bones of ruminants which it seemed to have gnawed ; a circumstance to be adduced in support of the opinion of those who believe that these hyenas lived and died a natural death in the cavern, and, consequently, that their carcasses were not washed into it by floods.

Next to hyenas, the animals most numerous represented in the Kirkdale Cave are—among the Carnivora,

the bear, wolf, fox, tiger ; among the Rodents, the hare, rabbit, water-rat, and mouse ; among the Ungulata, the elephant, rhinoceros, and hippopotamus ; among the Ruminants, the wild bull or aurochs, and three species of



SECTION OF KIRKDALE CAVE.

deer ; finally, among the Birds, the crow, pigeon, lark, duck, and thrush.

Another remarkable bone-cave is Kent's Hole, situated near Torquay, in Devonshire. Here has been found the greatest number of fossil relics of bears. Here, too, has been found a large carnivore, which M. de Blainville

refers to the genus *Felis*, and regards as a sub-genus of *Ursidæ*.

The other osseous remains are nearly identical with those discovered at Kirkdale, but we must add to the list the bones of bats, shrews, and field-mice.

We must not forget the Hutton and Banwell Caves, in the limestone chain of the Mendips, where our explorers have discovered, in addition to the specimens already named, a quantity of small bones, whose relative species have not yet been determined.

In Paviland Cave, Glamorganshire, has been found the skeleton, almost entire, of a stag, about as large in limb and body as the eland; and, in conjunction with the other species ordinarily met with in the caverns, the bones of the common mole and the harvest-mouse.

In Wirksworth Cavern, Derbyshire, has been exhumed the complete skeleton of a rhinoceros, which lay embedded in the midst of a considerable mass of gravel, and of bones, all whose species have not been recognized.

Lastly, we may refer to the Cave of Crawley-Rocks, near Swansea, in Glamorganshire, and to the Cavern of Yealm-Bridge, to the south-east of Plymouth, in Devonshire, where, besides a great number of bones of hyena, horse, ox, and the like, those of birds of large proportions have also been found.

THE BONE-CAVES OF FRANCE.

The first grottoes in France where fossil bones were discovered, would seem to have been those of Fouvent,

near Champplitte, in the department of the Upper Saône.

There are three grottoes at Fouvent. The first, called the *Trou de la Roche Sainte-Agathe*, is a passage about two hundred feet long, and six and a half feet wide, varying in elevation from two feet and a half to ten feet. The young women of the country make their pilgrimages thither. The second, named after St. Martin, assumes the form of a hemisphere, whose radius and height are each about sixteen feet. It is in the third, situated at the foot of the opposite flank of the valley, that a treasure was discovered, in 1800, of the fossil bones of elephant, rhinoceros, hyena, bear, and horse. These bones were described by Cuvier in his great work—the imperishable monument of that investigating genius which accomplished so absolute a revolution in geological science. In 1827 M. Thirria, engineer of the mines at Vésoul, carried out some fresh explorations in this cavern, and discovered there, in addition to the species already named, the bones of bull and lion.

In the same department occurs the Cave of Echenoz, two miles and a quarter from Vésoul, which is known, locally, as the *Trou de la Baume*. Here, in 1827, M. Thirria discovered a quantity of fossil bones. The mud which covers the soil of this cavern is intermixed with fragments of stalagmite—a testimony to the passing action of the running waters following upon an epoch of tranquil deposit of concretions.

The Cavern of Lunel-Viel, in the neighbourhood of

Montpellier, is, with the bone-caves of Kirkdale and Belgium, the one in which, as yet, the most complete aggregate of species has been discovered. In itself alone it contains nearly one-half of the hundred and odd species which compose the fauna of the European caverns. Some of the bones lay embedded in a clay diversified by black spots. This spotted clay has been skilfully and carefully analyzed by M. Ballard, the chemist, who has ascertained the presence of azotized organic matters—a fact only to be explained by supposing that portions of the carcasses must have been interred before the complete decomposition of the skeleton. The Cavern of Lunel-Viel, excavated in limestone of the Tertiary formations, scarcely attains, like that of Kirkdale, an area of some hundreds of yards. Its form is that of a long narrow tunnel of very moderate elevation.

We may name, in the department of the Gard, the Caverns of Pondres and Souvignargues, near Sommières, excavated in Jurassic limestone. Our explorers have found there, along with the species ordinarily belonging to the bone-caves, the fossils of a bear of very small size, which is rarely enough represented, and of wild boars, sheep, gallinaceous birds, land-tortoises, and lizards, in abundance.

In the same department is the Cavern of Mialet, near Anduze, where two species of antelope, about as large as the roebuck and the chamois, have been exhumed.

There are several bone-caves in the department of the Lézère, which have been described by Messrs. Marcel

de Serres, De Christol, Tournai, and Dumas. The richest in fossil memorials is that of Nabrigas, in the neighbourhood of Meyrincis.

The Cavern of Bize, in the department of the Aude, contains, or did contain, until plundered by the curious, a quantity of the bones of the horse, dog, domestic ox, reindeer, aurochs, and other animals. Among those of the horse, some authorities think they have recognized one which was probably domesticated. It was Marcel de Serres who seems first to have directed the attention of naturalists to the possibility of detecting, among equine fossil remains, several races which may have been trained and utilized by our unknown ancestors. In this cavern have been found also the bones of bats, mingled with the larger species of the cave-mammals.

Note, moreover, in the department of the Gironde, the Cavern of St. Macaire. It occurs in the Jurassic limestone, and is very rich in fossils.

And at various points in a deposit of grit, or sandstone, some leagues to the south of Corbeil, upon the outliers of the sandstone chain of Fontainebleau, bones of bears, hyenas, rhinoceroses, reindeer, entirely analogous to those of the caves, have been discovered.

BONE-CAVES OF BELGIUM.

The fossil bones of the different caverns of Belgium, which have been carefully studied by M. de Schmerling, resemble one another in species to a very great extent.

The Belgian caverns are very rich in bones, and, like

that of Lunel-Viel, exhibit, in themselves alone, one-half of the hundred and odd species which compose the fauna of the European bone-caves. M. de Schmerling collected from their deposits upwards of a thousand teeth: five species of bears have been determined—and two varieties, *Ursus giganteus* and *Ursus leodiensis*, besides those previously known, *Ursus spelæus*, *Ursus arctoidens*, and *Ursus priscus*; though it is true that M. de Blainville considers the specific differences indicated in the species of fossil bears as belonging only to age and sex. The mole, the harvest-mouse, the hedgehog, the glutton, the martin, the pole-cat, the dog, the catamount, the squirrel, the beaver, the ass, the tapir, the goat, the roebuck, the sheep, are also very common in these grottoes. We see there, in addition, two varieties of fox, five species of tiger, four species of campagnol, three species of ox, two species of stag, and the remains of eight species of different birds bearing a general resemblance to the duck, the goose, the cock, the swift, the crow, a very large bird of prey, and two small species of sparrow.

All the bones-caves of Belgium are situated in the province of Liège.

The richest, and the one in which the greatest number of fossil relics has been found, is the Cave of Chokier, near Liège. It is one of the most celebrated in existence; the one in which, perhaps, the largest quantity of bones has been found accumulated. It was of very inconsiderable extent; but no trace of it now remains, owing to the quarrying of the limestone rocks in the midst of which it was excavated. In this cavern, as in several of the Ger-

man and English bone-caves, alternate layers occurred of the bone-drift and calcareous travertine: the latter had even cemented in places, especially in the lower stratum, the mud, the gravel, and the bones, so as to form a veritable osseous breccia, which filled also the lateral fissures, and extended outside of the cavern, following the directions of the calcariferous waters. There was also remarked, as at Echenoz, the presence of fragments of stalagmite in the mud, carrying with it a similar geological lesson.

Next to the Cavern of Chokier, the most celebrated bone-caves of Belgium are—those of Engis and Engihoul, on the Meuse; and those of Fond de Forêt and Goffontaine, on the Verdre. It is in the latter, more particularly, that the bones of bears have been found in great abundance.

BONE-CAVES OF GERMANY.

Cuvier has made the remark that three-fourths and more of the bones of the caves of Germany belong to the *Ursidæ*, one-eighth to a species of hyena, and the remainder to different kinds of carnivores. The frequently prodigious quantity of the ursine relics, which belong evidently to many generations, and yet do not appear to have undergone any external alteration, has led some paleontologists to suppose that these animals wholly resided in the caves; or, at all events, that they took refuge in them in great herds, and were surprised there by sudden and violent inundations.

The most numerous and the most celebrated bone-caves of Germany are situated in Franconia and Carniola.

Among these we shall place first, in point of interest and importance, the celebrated cavern of Gailenreuth,

near Muggendorf, in the county of Bamberg, in Franconia. Herr Goldfuss has discovered there the osseous remains of nearly one hundred individuals of a single species of bear (*Ursus spelæus*). In this cavern, moreover, as in that of Kuhloch, another of the Franconian curiosities, the same fact has been noted which we have already seen at Lunel-Viel : the occurrence of blackish spots in the clay in which certain groups of bones were embedded. The careful and skilful analyses of this spotted clay of the caverns of Gailenreuth and Kuhloch, made by Messrs. Langier and Chevreuil, have demonstrated the presence of azotized organic matters ; and hence it has once more been inferred that parts of some of the carcasses must have been engulfed prior to the total decomposition of the skeleton.

Among other remarkable Franconian bone-caves we



CAVERN OF ERFSFINGEN.

may refer to that of Ra-burstein, not far from Gailenreuth, and that of Brunberg. The fauna of these caverns is identical with that of Gailenreuth ; only, it is less abundant.

In Wurtemberg, we find the caverns of Erfsfingen and Wittingen, where the principal remains are those of the bear, dog, fox, polecat, lynx, stag, roebuck, ox, and sheep.

In Westphalia, we shall cite the cavern of Sundwich and the Kluterhohle ; in the duchy of Brunswick, that of

Baumann, on the north-east declivity of the Hartz mountains, and that of Scharzfelds, near Göttingen, on their western face.

Lastly, not far from Jena in Saxony there exist, in the gypsum of Kostritz, certain vertical cavities, in which have been discovered the bones of the mole, the martin, the weasel, the squirrel, the hamster, the rat, the rhinoceros, the stag, the goat, the hen, the owl, and the frog. There,



THE KLUTERHOHLE, WESTPHALIA.

too, have been observed the remains of bats, mingled with those of the larger species of the cave-mammals.

CAVERNS IN WHICH HUMAN BONES HAVE BEEN EXHUMED,
AND VESTIGES OF HUMAN INDUSTRY.

By no means few in number are the caverns in which have been discovered the traces of man and his industry, either with or without the remains of extinct mammalia : they exist in England and Germany, as well as in France ; but it is in France that the most numerous examples have been found, at least up to the present time.

The vestiges of human industry exhumed in these subterranean retreats generally consist, in addition to the coarser fabrics of the Celtic epoch—such as flint weapons, bone needles, collars of shells or animals' teeth, and rudely baked pottery—of objects incontestably of Roman origin; such as statuettes and lamps in bronze or terra cotta, bracelets of jade or metal, ornamented vases in red ware, glasses enriched with coloured enamels, and similar productions of Roman art.

The most interesting of these caverns we shall pass rapidly in review; and afterwards we shall briefly indicate the conclusions which, we think, may be deduced from the presence of these memorials of human handiwork.

In France we turn, first, to the Caverns of Périgord and Quercy, where numerous indications have been found of the residence of the Gaulish population both before and during the Roman domination,—among others, a great quantity of weapons made of flint. In the Cavern of Brengues was found, along with remains of mammals, a human skeleton. In the Caverns of Languedoc, human bones in the same condition and at the same degree of alteration as the bones of mammals; specimens of pottery, some of which appear to have been submitted to the wheel; bones of horse and stag wrought by the hand of man; and marine shells. In those of the Vivarais, fragments of coarse earthenware, and of carved Roman tiles. M. Marcel de Serres has proved the existence in the Caves of Fausan of glasses coated with coloured enamels, and of pottery, mingled with bones of extinct species of bears. In the Cavern of Mialet have been

found, along with relics of bear and hyena, human bones, as well as objects of art, pottery, lamps, a statuette in yellow terra cotta—representing a senator attired in his toga—mingled with other objects of Gaulish origin, such as flints and jades wrought by the labour of man. Finally, in the Cavern of Durfort human bones have been exhumed, piled together as in a charnel-house or ossuary.

In England we may point to the Cave of Paviland (Glamorganshire), where was disinterred a female skeleton, almost entire,—accompanied by numerous rude articles which seem to have served the purpose of personal adornment ; such as little ivory ornaments, bone pins, a great quantity of small nerites, and of larger marine shells. At Barrington the explorer was rewarded by the discovery of a considerable number of human skeletons. At Vokey and at Swansea the researches of science have led to the exhumation of human bones, broken, and cemented by red clay and stalagmitic deposit ; while in the little Grotto of Lloeandefir, in Caermarthenshire, twelve human skeletons of unquestionable antiquity have been disinterred.

In Germany we must particularize the Caverns of Gailenreuth and Zahnloch, in Franconia ; where, about 1774, were found a layer of charcoal and heaps of fragments of urns of different shapes, but most of them of rude workmanship, and apparently of German design : a few, however, resembled lachrymatories, and hence must have been of Roman origin. In a recess of the same cavern some human bones, and even entire skeletons, were dug

up, which seemed to have been deposited there as in a place of sepulture. In the gypsum caves of Kostritz, several human skulls, which were pronounced by the learned to have belonged to the race of Goths, were detected in a pile of the bones of various species of mammalia. And, recently, the existence of human remains in the two bone-caves of Wittingen and Erfsingen, in Wurtemberg, has been placed beyond doubt.

In Belgium, the Caverns of Engis, Chokier, and Fond de Forêt, have offered a treasure-trove of human bones, of deer bones wrought by the human hand, and of flints fashioned into knives and arrow-heads, mingled in the mud and gravel with the bones of the larger mammals.

Now, must we conclude from this concurrence, in the bone-caves, of human bones and vestiges of human industry along with the osseous remains of mammals now extinct, that Man was a contemporary of these mammals,—in other words, that Fossil Man exists? It was about 1830, after the first discoveries made in the caves of the south of France, that such an hypothesis was advanced by several paleontologists; and it is now supported by physicists and ethnologists of the highest reputation,—Messrs. Boucher de Perthes, Joly, Simonin, Sir J. Lubbock, Professor Huxley, Sir C. Lyell,—as well as by the majority of our scientific men. It seems to us impossible to resist a conclusion deduced from indubitable facts, and we are of opinion that the existence of Prehistoric Man has passed from the region of doubt and theory into that of absolute certainty.

CHAPTER VII.

COAL AND COAL-MINES.

Formation of coal—Growth of peat—Submarine forests—Reconstruction of the primeval world—Resemblance of the African forests to those of the ancient coal-measures—Deposit of coal—Development of the beds—Early history of coal as a combustible—Production of coal in Belgium—The United States—Coal in Great Britain—In Central Europe—In France—In Africa—In Hindustan—Some statistics—Coal-basins—Discovery of their position—Excavating a coal-mine—Working a coal-mine—Various systems in various countries—Life in the coal-mines—The miner: his labours, habits, and character—Perils “beneath the surface”—Choke-damp and fire-damp—A catastrophe at Mons—Landslips and floods—An anecdote—Tragedies in the coal-pits—The calamity at Lalle—A record of accidents—A liquid combustible—Petroleum—Oil-wells in the United States and Canada—Their variable product—The story of Shaw, the American—A catastrophe at Idiona—Uses of petroleum—Attempts to employ it as a combustible—Petroleum and steam navigation—The present and the future of coal—Diminution of the coal supplies of Great Britain—Probable discovery of a substitute for coal.

NEARLY all the great geological phenomena which have determined the formation of the terrestrial crust are still in course of gradual operation at the present epoch. Thus, the mechanical convulsions which have driven the waters back from our ancient shores, are now represented by the upheavals of the soil, by volcanic outbursts, and earthquakes. The slow generation of the rocks takes place under our eyes, through the sedimentary deposition of the rivers and seas: but these modern phenomena, it must be owned,

have not the powerful action of the ancient ; the movement is retarded, the effect is weakened—is, in fact, more than a remote reminiscence of *what was*.

The formation of peat, which takes place under our eyes, exhibits, undoubtedly, some striking analogies to the formation of coal, and its study affords us some valuable *inlooks* into the creation of the immense carboniferous deposits, on which so much of human happiness and civilization depends.

Most peat-fields occur in the low plains, where the waters pass away very slowly and with difficulty, and where, in general, they are exceedingly shallow. Such are the vast peat-fields of Chat Moss, of Ireland, of Lanarkshire, of the basins of the Somme, the Seine, and the Loire. Sometimes, however, peat is produced on the declivities of hills and mountains abounding in a thick growth of low, rank vegetation. This vegetation acts like a sponge, and constantly holds a sheet of water in which it is decomposed. The moorlands of Yorkshire and the Scottish Highlands, of the mountainous districts of France and the Vosges, have thus originated; but in such localities the growth of peat is not so rapid as it is on the level and low-lying plains.

M. Elie de Beaumont has shown that in the stagnant waters where peat is created two kinds of vegetation spring into life : the one at the bottom is engendered by aquatic plants ; the other, on the surface, by terrestrial plants, which take root upon a kind of solid raft, formed of floating leaves and dead wood, enlarged by an infinity of organic débris. Once these terrestrial plants are thoroughly developed, a superficial layer of greens

forms, and day by day is consolidated ; this solidity constantly increases, and in due time is sufficient for the support of tolerably tall trees. If you traverse the shaking strata of soil thus superimposed on sheets of water, you perceive that they are elastic and sonorous, and that the slightest depression you make in them fills immediately with stagnant liquid.

To explain more clearly this phenomenon of peat-growth, we may describe its internal structure. The superficial verdure forms, then, as already hinted, a solid and elastic surface, underneath which sleeps the motionless water, filled with plants growing upwards from the bottom, and roots striking downwards from the sward ; these plants and intertangled roots form a spongy kind of matted growth. At the bottom of the water are developed the aquatic plants, which increase the density of this growth, and whose successive decomposition incessantly augments the thickness of the peat. This peat spreads itself out in layers, in proportion as it is produced and as it exhausts the depth of the peat-bog.

The appearance of the peat is very various, according to the nature of the plants which compose it. *Mossy peat* is the more abundant : it is formed of creeping plants, agglomerated and interlaced. *Leafy peat* is, in the main, produced by superimposed leafage, and we find in its substance the trunks and branches of the trees from which this leafage fell. Generally the trunks are distorted, flattened, and recumbent ; however, they are occasionally found erect, like the fossil trees met with in coal.

Frequently these deposits are improperly called *sub-*

marine forests, because they are often found on the shores of ocean, at a lower level than that of the waters; but they are constituted wholly of terrestrial vegetation—of oaks, pines, birch—transformed into peat, which the sudden inundation of the tide, or the pressure of the sands, or some natural convulsion, has profoundly embedded in the bowels of earth. St. Michael's Bay, on the coast of Normandy, offers a beautiful geological example of the submergence of peat. It is situated beneath the surface, and behind the *levées*, or banks of pebbles and shingle, which the storms and hurricanes of past ages destroyed. At the Roman epoch it is known that the area of this bay was the site of a magnificent forest; but the littoral *levée*, overthrown by the violence of the waves, towards the beginning of the eighth century, submerged this forest, whose peaty soil was speedily invaded by the sands, and in the present day it is under the dunes and during a gale that we discover it—the receding billows then expose the ancient formation, and dashing heavily against the shore, tear up and scatter abroad fragments of shattered and blackened timber.

It is not impossible that, one day, these peat-bogs will be converted into coal, and our descendants draw infinite wealth from deposits which are now only in course of formation. Putting aside the mineralogical difference of the products, there is no obstacle to the assimilation of the conditions under which coal is created to those which give birth to peat. This hypothesis will suggest itself to almost every reflective mind; and it

derives support from a close observation of the *modus operandi* of Nature, which, in its manifold creations, shows us the action of the same causes producing the



IMPRESSION OF A FERN FROM THE COAL-MEASURES OF THE HARZ.

same effects. The gradual formation of peat is, perhaps, the image of the formation of the primeval deposits of

coal; and thus, before our eyes, we have the impressive picture of the action of the natural forces, which labour patiently, age after age, and, aided by the influence of time, accomplish immense works. If this conjecture be authentic, it confirms the grand idea of the illustrious Leibnitz, who looked upon the present as a mirror in which the past was reflected to shadow forth the future.

A careful study of the impressions of divers ferns and trees does not only permit us to demonstrate beyond doubt the origin and development of coal, but enables us also to reconstitute in our thought the vanished conditions of



LEPIDODENDRON.

the elder world. Pompeii and Herculaneum, long buried deep under the lava and ashes of Vesuvius, spring into busy life again before the eyes of the historian who describes the mansions of those cities of the dead, and who sees the crowds of eager citizens once more awoken to re-people the streets now so silent and desolate. In like

manner the fossils of the coal-measures seem to start from a prolonged repose to present themselves to the inquiring gaze of the geologist, the chronicler of nature; and, at the bidding of science, the ferns lift up their arborescent branches, and the lepidodendrons their slender and flexible stems, while the verdurous lycopodiaceæ bathe

their roots in the freshness of the surrounding marshes. Earth, from pole to pole, is covered with a thick mantle of verdure, and the plants of the Carboniferous period are resuscitated by the voice of the geologist. The vast continents clothe themselves with an immutable and a prodigious shadow.

Exceedingly strange was the decoration which then embellished the landscapes of the growing world. The plants which now are humblest were then the haughtiest; the ferns of the present day are but poor and decrepit representations of the primeval ferns; while the lowly growth of our marshes is the miniature image of the gigantic reeds which then overspread the soil. The plants of the primeval world exhibited an impressive uniformity; there was even a grandeur in the very poverty of their species. Nature, prodigal of strength and fecundity, seemed avaricious of variety. There were neither fruits nor flowers, to introduce the grace of contrasted colouring; no terrestrial animals to enliven by their movements the terribly still forests. Vegetable life, motionless and apparently eternal; upon the continents, a marsh, a swamp, scattered here and there; beyond, the limitless sea. Not a bird made melody amongst the leafy boughs; not a mammal sought the pleasant shelter of the groves; ocean alone was peopled with numerous inhabitants. A few insects fluttered their irradiant gauzy wings above this organic world, but the majesty of the forests was troubled by no superior creature. Not a living foot stirred the leaves which encumbered the ground; and not a thought, not

an imagination, dwelt upon the uniformity of ~~the~~ singular world.

In Tropical Africa some forests still exist in which ~~the~~ trees present a remarkable analogy to those of the ~~Car-~~boniferous period. Dr. Livingstone has graphically ~~de-~~scribed the curious plants which he discovered in ~~the~~ heart of the unexplored regions of the vast African table-land. The humidity of the air, and the excessive heat, overcome the bold pioneer of civilization who dares to penetrate into this land of luxuriant vegetation. The tremendous rains and the arrowy beams of a burning sun prostrate the strength of the European ; but there a genial nature loves to develop the inexhaustible character of her resources.

On this vast African table-land is written, as it were, the history of the forests of the coal-measures ; we may see the last vestiges of a departed world. But the atmosphere is no longer identical with the antediluvian atmosphere, which was heavily charged with carbonic acid, a gas specially adapted to give to plants a wholly exceptional vigour and development.

The rapidity of growth of the primeval plants, the activity of their development, the grandeur of their proportions, the immensity of their extent, suffice to indicate to us the condition of the atmosphere in the elder world.

It must have been saturated with humidity and charged with carbonic acid gas, which, in conjunction with a high temperature, necessarily favoured the development of vegetation. Rain in abundant torrents flooded the continents, fertilizing the forests which flourished on the low shores of the estuaries, on the margin of the

great inland lakes, and amidst the verdurous water-courses.

Under the influence of the solar rays, the plants of those distant ages reduced the carbonic acid. They assimilated the carbon contained in it, and by thus purifying the atmosphere, prepared it to nourish higher forms of life. This reduction of the carbonic acid operated simultaneously with an absorption of heat on the part of the plant. The heat, stored up, remained in a latent state, to become active when man, in the fulness of time, made use of the black combustible. When we ignite coal, it burns ; it combines with the oxygen of the atmosphere, and evolves heat ; and we may say, without being paradoxical, that this heat is no other than that of the antediluvian solar rays, concentrated for ages in the bowels of the earth. It is now disengaged to quicken the industry of modern society.

For what purposes, and with what designs, were these majestic forests developed ? For what object, and to what end, prospered these solitary shadows ? The problem is insoluble, the enigma without a key,—at least for those who cannot accept the common hypothesis that everything in nature was made for man. And here we may ask, Is it more prudent to take Buffon as our guide, or to imitate the good sense and clear judgment of Fontenelle ? “ We are all,” says that profound philosopher, “ made naturally like a certain Athenian lunatic, who took it into his head that every ship entering the port of Athens belonged to him. *Our folly is to*

believe that all nature, without exception, has been created for our use ; and when we ask our philosophers the utility of such a prodigious number of fixed stars, of which a portion would suffice to do that which they all do, they coldly reply that they serve to rejoice the eye ! ”

Is it not also folly to imagine that these deposits of coal have been created only for our benefit—to indulge in ecstasies over the accumulation of these antehistoric remains—an accumulation in the bosom of the earth designed, as we say, for the profit of human industry ? If we look at things in this light, we may proceed to a very wild extreme, and, so proceeding, shall find ourselves logically led on to assert that the cork-tree was created, tens of thousands of years ago, in order that man might one day manufacture corks ! We must be on our guard against silly sentimentality when we are studying nature. We must beware of thinking that everything in this world gravitates around a circle of which man is the centre. Do not ask why coal was produced, but thankfully employ the forces which it places at our disposal.

Gradually engulfed beneath the surface, the antediluvian forests withered and dried up, and slept in their hidden sepulchre for myriads of years ! Who, we wonder, first discovered these relics of a departed time ; who first excavated these immense deposits, who extracted from its resting-place the first block of coal ? It is Nature, say our moralists, which revealed to man the treasures lying underground ; and Great Britain, we are told, the

Land of Coal, first turned to advantage the precious fuel. "The waters," says Whitaker, in his "History of Manchester," "frequently bring down from the summits of the mountains the projecting extremities of the coal strata which lie upon the surface, and the Britons could not fail to notice those shining masses, and, either through chance or reflection, find out their utility. Another and more positive proof results from the recent discovery of several blocks of coal, embedded in the sand, beneath the Roman Way of Ribchester."

In 1239 Henry III. granted to the inhabitants of Newcastle-upon-Tyne his royal charter for working the adjacent coal-mines, which daily grew in value and importance.

From these statements it would seem that coal was worked at a much earlier date than the Belgian chroniclers admit. These assert that its discovery is due to a smith named Hullos, who lived in 1049. We cannot pretend to determine who is in the right. However this may be, when man had once acquired a knowledge of the properties of coal, it was not long before he turned them to advantage.

Of course, in countries where coal lay at or near the surface, it was known from the earliest period. But though it was known, it was not worked. For a regular system of coal-mining to be established among a people, it is necessary that their civilization shall have attained a certain degree of perfection : it is necessary also that a commerce which exports, or an industry which consumes, shall be in existence. According to tradition, it was

Flanders, the first country really industrial, which worked the first coal-mines. Coal would seem to have been worked in the neighbourhood of Liége in the twelfth century; and the first miner figures in numerous old legends as the *Prudhomme Houilleur* or the *Vieillard Charbonnier*. In the fifteenth and sixteenth centuries the workings extended from Liége to Mons, giving a most vigorous impulse to the commercial prosperity of the country.

If Belgium was the first producer of coal, it would seem, however, that France was its first consumer; and it was for the purpose of sending coal to Rouen that the English coal-mines were originally worked.

The United States have been wonderfully favoured by Nature, who has accumulated within their borders every kind of wealth; and the coal-basins occupy no inconsiderable portion of the immense area of that mighty republic. But in these new lands, the history of which has hardly yet begun, men hitherto have not utilized one-tenth part of the precious resources lying beneath their feet, nor have they even ascertained their exact extent. What would it profit to compute their riches, when they know that the wildest prodigality can consume only a comparatively small portion? In America there are coal-fields as far north as Greenland, as Baffin's Bay, ay, even as the Pole! Further south, on the Pacific coast, we meet with the coal-treasures of California, situated in a peculiarly favourable locality. Near the great Bay of San Francisco we find the deposits of Oregon, which

man hands have hitherto respected. What a future is in these immense mines! Now that the Pacific railway has linked New York to San Francisco, opening up to London the nearest route to Pekin, the fossil deposits of California, situated close to the great ports, may supply the whole world.

To the United States belong the largest coal-fields in the world. They stretch around the great Salt Lake, where the Mormons work them. They are sunk deep in the soil which borders on the Gulf of St. Lawrence. They are developed at the base of the Alleghanies, as far as Missouri, as far as Arkansas, until they touch the foot of the Rocky Mountains. They invade Pennsylvania and Virginia, states which owe to King Coal much of their richness and prosperity. They furrow the territories of Illinois, Indiana, and Missouri. Everywhere they appear potent and massive, and prepared to enrich the new nation.

The coal-fields of the United States are eight times more extensive than those of the whole world. Though they have been worked for forty years only, they yield a product nearly equal to that of the mines of France and Belgium. They occupy one-fourth at least of the immense superficies of the United States. They are vast storehouses of abundance, on which our sons may draw freely.

Next to the United States we must place our own islands, or at least Great Britain,*—the Black Country,

* It was estimated in 1871 that the available quantity of coal remaining in the British coal-fields amounted to 146,480,000,000 tons.

the Land of Coal,—which pours its millions of tons into Hindustan, Australia, all Europe—the whole world. The two largest coal-fields of England lie on the very border of the sea, and the coal-laden trucks glide right down to the vessels which carry their contents far across every ocean. And another special advantage is, that close to our coal-fields lie our stores of iron. Iron and coal! A happier conjunction than that of gold and silver! With bread and iron, said Buonaparte to his warriors, one might conquer the world: what may we not accomplish with coal and iron?

One of these great deposits is situated in the west, and forms the famous Welsh basin, which sends its “Cardiff” to the uttermost ends of the earth. The other extends towards the east; this is the Newcastle basin, which in itself alone produces as much coal as the whole of France! Here King Coal reigns supreme over an army of 40,000 labourers, who live and prosper at his expense; while Swansea, a century ago an insignificant fishing-village, has become, thanks to coal, one of the centres of the iron manufacture. She sends her ships to double Cape Horn, and bring back the ores of Chili; it is for her and her merchants that the negroes of Cuba toil, and the free populations of Coquimbo and De la Paz; while it is to coal, and to coal alone, that she owes her prosperity.

Belgium is rich in coal-beds, which yield every variety of that combustible, besides one peculiar to the country, the *fleuve*; a very useful coal, much esteemed by the manufacturers of Paris.

The Belgian coal-basin, widely developed between Liège and Mons, stretches from east to west over a length of nearly one hundred and ten miles. Throughout this extent the soil literally *bristles* with factories, machine-works, and industrial establishments. Seen from a distance, the tall brick chimneys rise so close to one another as to suggest the idea of a fleet of high-masted ships, or of a series of lofty isolated trees.

Central Europe abounds in coal-deposits; and Prussia possesses the important mines of Sarrebruck, Aix-la-Chapelle, and Silesia. France also counts some valuable fields, such as those of Rive-de-Gier and Saint Etienne. The immense basin between the Rhone and the Loire is almost wholly composed of coal. The black stratum rests, on the one hand, on the escarpments of Mount Pilatus, and on the other touches the chains of the Lyonnais and Forez. On leaving Lyons for Givors, the traveller, as he draws towards Rive-de-Gier, observes a sudden and striking change in the aspect of the country. He sees shafts and the galleries of mines, and heaps of scoria, and forges, and machinery of the most complex character, everywhere around him. The soil is black; and the faces of all whom he meets, as well as all the objects on which he rests his eye, wear a coat of coal-dust. From a hundred furnaces the red flames leap into the air, and at night the sky is reddened as if the earth were on fire, or as if some great volcanic eruption convulsed the surface of nature. The very atmosphere is affected by the coal-workings, for an infinite number of chimneys are constantly pouring forth torrents of fuli-

ginous smoke and unwholesome vapour, which gather into an immense and obscure cloud, and rest like a massive canopy over the gloomy district. But why need we dwell on the details of a scene which is surpassed by the spectacle ever present in the mining districts of Staffordshire, in the neighbourhood of Leeds, in the black country round about Coatbridge and Airdrie? Few of our readers but must have witnessed it at some time or other, and have made themselves familiar with its wonderful and interesting aspects.

At the end of the sixteenth century Saint Etienne was a little hamlet, containing about a hundred inhabitants, famous for their skill in the fabrication of tools and weapons. *Now* it is crowded with a population of one hundred thousand and upwards; and undoubtedly this astonishing development is due to coal.

While Saint Etienne supported with difficulty its five-score of souls, Rive-de-Gier and Givors were not even in existence. These two important towns have been created by the might of the twin giants, Coal and Iron.

Epinac and Blanz, in the department of Saone-et-Loire, must also be included among the more valuable coal-fields of France.

In their vicinity is situated Creuzot, the domain of M. Schneider, one of the celebrities of the "Second Empire." Wholly unknown a century ago, it has become, thanks to coal, the seat of a flourishing industry. Upwards of ten thousand workmen live upon this wide table-land, and labour at the extraction of coal and iron ore, at the manufacture of cast-iron and steel, at the construction of



FRENCH COAL-MINERS AT WORK.

those wonderful machines which have so largely increased the resources of trade and commerce.

We pass on to the department of Gard, and tarry for

a moment at the fine coal-fields of Alais and the Grande Combe. In Aveyron we note the productive basin of Aubin. We glance hastily at the great establishments of St. Chamond, Carmeaux, Brassac, and the Moselle, and so complete our survey of the carboniferous treasures of France. Less rich "beneath the surface" than the United States and our own little island, it is richer than Spain, Italy, and Greece; and as manufactures prosper in proportion to the abundance or deficiency of coal, as a manufacturing country it is superior to all the countries of Europe except England.

In Africa carboniferous deposits of some importance have been discovered at the Cape of Good Hope, on the coast of Mozambique, and along the banks of the Zambesi. We cannot speak with any certainty, however, of the subterranean riches of a continent whose very surface is imperfectly known. How many courageous explorers, burning with a desire for knowledge, and anxious to immortalize their names, must traverse the wastes and wildernesses, the fertile plains and rich valleys of Africa; how many successors of Speke, Livingstone, and Baker must investigate the geography of its lakes and rivers, before human industry shall burrow beneath the surface of that yet virgin soil, and human science map out the distribution of its mineral treasures!

It is known that coal-mines exist in the great island of Madagascar; but hitherto that singular state has opposed an insuperable barrier to the progress of European civilization, and its subterranean wealth lies neglected and

useless. Its inhabitants appear to cherish some superstitious dread of mines and mining. Any stranger who is not a miner they tolerate, if they do not welcome ; but they punish with death even the innocent well-sinker, though unable to explain the cause of a cruelty apparently so trivial and absurd. But though the exact locality and extent of the coal-fields of Madagascar have not been ascertained, it is certain that they are considerable as well as rich.

Important mines abound, too, in Hindustan, in the Burmese Empire, in Cochin-China, in the "Flowery Land," in Japan, in Central Asia, in Siberia, and Persia, as well as in New Zealand, and some parts, it is said, of Australia. These deposits are being worked on a more or less extensive scale, particularly in Hindustan, where the mining industry has received every encouragement from our rulers ; but we have as yet no precise data by which to calculate their extent. But we know that they form precious reserves for the future. Meantime, the following table shows the relative importance of the principal European coal-fields from which the world obtains its present supplies :—

	Superficial Area.	Annual Production in Tons.
The British Islands.....	1,570,000 hectares.*	110,000,000
Russia, Saxony, and Bavaria.	600,000 "	20,000,000
France.....	350,000 "	12,000,000
Belgium.....	150,000 "	12,000,000
Austria and Bohemia.....	150,000 "	3,000,000
Spain.....	150,000 "	400,000

* A hectare is equal to two and a half acres (nearly).

In the distribution of the coal-deposits the reader will observe a curious circumstance,—their accumulation in the *northern* hemisphere. The most extensive fields, in fact, are concentrated in North-Western Europe, between the forty-ninth and fifty-sixth parallels of latitude ; and as we advance towards the south they decrease in number, area, and importance.

The comparatively insignificant basins of Andalusia are the last we meet with in that direction, for, as we have said, those of Africa are little known.

It would seem as if some singular incompatibility existed between the carboniferous formations and the southern hemisphere ; but then, on the other hand, they are now known to occur in Australia. To what cause shall we ascribe this irregular distribution of the earth's mineral treasures ? It is needless to say that no satisfactory reply can be given. In all such cases science must limit herself to ascertain *facts*, and not involve her disciples in a fruitless pursuit of *reasons*. The universe has its mysteries, which will not reveal their secrets even to the ardent enthusiasm of the philosopher.

The areas, frequently of great extent, occupied by this invaluable mineral, are known to geologists by the name of "coal-basins." Sometimes the coal and the rocks with which it is united fill the beds of ancient seas or of dried-up lakes ; and the deposits which sink deep into the bowels of the earth appear, at other points, on the very surface,—lie exposed, as it were, to the light of day ; and in such instances the coal-mines are all known and worked. Sometimes, however, the black fuel is concealed

beneath the soil : to the inexperienced eye not a sign reveals its existence ; nothing, on the surface of the earth, would lead you to suspect the presence of subterranean riches ; and then, it is chance or science which leads to their discovery. Thus, in 1813, in the department of the Sarthe, in France, the sinking of a well opened up an abundant deposit. Among the refuse brought to the surface a quick eye remarked a blackish substance, and recognized it as coal. It burned, in fact, with a brilliant clear flame, and the fortunate owner of the estate found a fortune at the bottom of his well !

In other cases, science is the miner's guide : geology indicates to him certain probabilities, which he verifies by soundings and patient borings ; these direct the hand of man to the depths of the earth, and frequently place him in possession of what Dr. Johnson called the "potentiality of wealth."

These borings, these sinkings, these shafts have revealed the deposit of coal ; we know its extent ; we suspect its thickness : the next step is to render it available for the purposes of human industry. We begin by excavating a certain number of *shafts*, and by opening up *galleries*, or tunnels, in the solid mass ; and when the stratum is compact, and the upper rock hard and resistant, the work is laborious and difficult—we advance very slowly and progressively. When the soil is friable, and the rock soft and crumbling, like the sandstones and schists, the shaft must be walled-up, and the works are not carried on without much embarrassment. If we meet with subterranean sheets of water, our perils necessarily increase ; dykes must be constructed to prevent

their inundation, and huge pumps erected to draw them to the surface. Sometimes our operations must be carried on through disintegrated sands and crumbling earths, and then they become a very miracle of patience and perseverance. But nothing daunts the miner. He seems to gain fresh enthusiasm from every difficulty ; to encounter each new obstacle with added energy. Born for a life of struggle, he loves battle and conflict ; he rejoices in the sight of the barriers his unflinching industry will overthrow ; the more arduous the work, the more he congratulates himself on the result obtained at the cost of indescribable exertion.

As soon as the shaft is completed, and success has crowned his toil, great is the miner's joy. He has won the first victory, and may reasonably look forward to an adequate recompense.

But as the shaft, if neglected, would speedily fill with water, pumps must be erected to provide for its regular exhaustion. Here the steam-engine comes to his assistance. Day and night the piston maintains an incessant motion ; day and night the pumps are at work, and struggle against the elements which, like the dragons of fable, close the road man has had the audacity to open up. The mining-pump now in use resembles in every detail the machine which sprung from the genius of James Watt. Not a modification has been found necessary ; not an improvement has been required.

The difficulties, the perils, the unforeseen obstacles, which beset the miner in sinking the shaft, are still around and about him as he excavates his subterranean galleries ; are, in truth, far more formidable, and far less

easily overcome. In this horizontal excavation, the *pressure* is greater, and, consequently, the *danger*. When the gallery is opened in a schistous formation, it shows a natural tendency to close up; for the weight of the superjacent soil acts with an inconceivable potency, and sometimes a gallery in which, to-day, a man can stand upright, will not, on the morrow, afford a passage for a mouse.

To guard against these dangers, the galleries must be walled or shored-up in the same manner as the shafts; tunnels of stone or brick must be constructed, roofs supported, timber frameworks erected. In different parts of the subterranean gallery the miner builds strong and solid frames in the shape of a trapeze; the wood used is not planed or hewn, but rough as it comes from the timber-yard. The space between each trapeze is lined with horizontal or vertical beams, so as to constitute in the whole a substantial corridor of wood, divided into various compartments, and shut off from each other by a massive door, which may be utilized for ventilating purposes, or to check the diffusion of noxious vapours.

When the shafts and galleries have been opened and strengthened, the steam-engines planted on the surface of the soil, and the great pumps set in motion, the coal-field is available for the industry of man, and its owner may seek a return for the capital he has expended. Some shafts cost in construction as much as £80 per cubic yard, and are ten times the height of the Roman Pantheon. Galleries there are which cost in construction not less than £20 per cubic yard, and exceed a league in length. The carboniferous deposit is a mine of gold;

but at what a price it is worked ! Thousands of pounds are sunk in the shafts before the treasure can be reached.

When coal was first made use of, there is no doubt that it was extracted in the rudest and most barbarous fashion. The earth, to use an expressive term, was simply *scratched*. If galleries were dug, they were narrow and near the surface ; and the miner, a slave or a criminal, slowly pounded away at the rock with a rough and inadequate tool. Lying upon his side, with his head bent, he struck incessantly at the black rock above him, and the fragments thus accumulated were painfully removed to the surface. The toil was torture, and the French have branded it with a most significant epithet—*travail col tordu*. It is but a few years since this frightful mode of working was abandoned ; and even in Scotland, unfortunate children might be seen carrying upon the shaking ladders their baskets loaded with coal.

In the richer coal-beds a method of working, certainly not less barbarous, was employed in France, and elsewhere, until within the last few years, known as the *méthode par éboulement*. Armed with pickaxes, the miners hewed out a great block of coal, working away until it was on the point of falling, and then hastening to some secure corner for a temporary refuge. But it was necessary to prop up the immense voids thus created, and to guard against the formation of crevasses, which opened sometimes to the very surface of the soil, and provided the surface waters with a ready access to the coal-pit. Moreover, at least two-thirds of the coal were abandoned

in the mine, as props, buttresses, or pillars ; and the increasing demands of commerce have led to the abandonment of a process not only dangerous but wasteful.

Of late years mining has assumed the importance of a science. The safest and most economical modes of working are carefully studied. The miner's security is provided for by many ingenious appliances, and his industry is amply rewarded, while his hours of labour have been considerably diminished.

We have hurriedly glanced at some of the principal obstacles over which the miner's energy and perseverance triumph ; but altogether apart from these, he meets too frequently with other and far more formidable enemies, which are able, in a moment, to destroy the work of many years.

To extract from the deposits entire blocks of coal, the miner is compelled to have recourse to gunpowder, which, by its combustion and consequent expansive force, loosens from the solid rock enormous masses of the jet-black combustible. But gunpowder is a terrible weapon, which sometimes turns against its employer.

The miners bore in the walls of their subterranean galleries a certain number of deep but narrow holes. These they fill with gunpowder ; and the gunpowder, by means of a fusee, they ignite. As soon as the fusee catches fire the miners withdraw, and wait for the explosion which will facilitate their work. Not infrequently, however, the match, if compressed too closely, does not burn properly ; the explosion is deferred ; and the miners must then approach the scene of danger to ascertain and remedy the

cause of the delay. The reader will at once perceive what terrible accidents may be the result of this venturesome task. The powder may explode just as the workmen reach the match, and the fragments of coal, hurled abroad like a shower of shot and shell, scatter death or wounds among them.

When the operation takes place in due course, the spectacle is one of sublime magnificence. A roar, like the artillery of a great army, is heard. The dilatation of the gases set free by the gunpowder disperses enormous blocks of coal, as if they were flakes of snow. A dense smoke rises into the atmosphere; then a dead calm succeeds to the tumult. The pickaxe comes to finish the work begun so effectively by the gunpowder, and with the loosened fragments the coal-waggons are speedily laden.

This process of "blasting," as it is called, is the frequent cause of terrible conflagrations in the coal-pits. But such outbreaks are sometimes spontaneous, and originate in the decomposition of the coal. When the small coal remains for any length of time in the pits, it grows heated under the influence of fermentation, and the temperature rises even to the point of combustion; the fire feeds itself, and continually obtaining fresh supplies of fuel, it is propagated with a terrific intensity. To contend with this formidable enemy, the miner closes the galleries with walls of clay which define and limit the field of disaster; but what courage and what resolution are necessary for the erection of these barriers in the very face of the incandescent furnace, which heats the entire mine, and frequently raises the temperature to 108° F.! The workmen strip themselves to the skin,

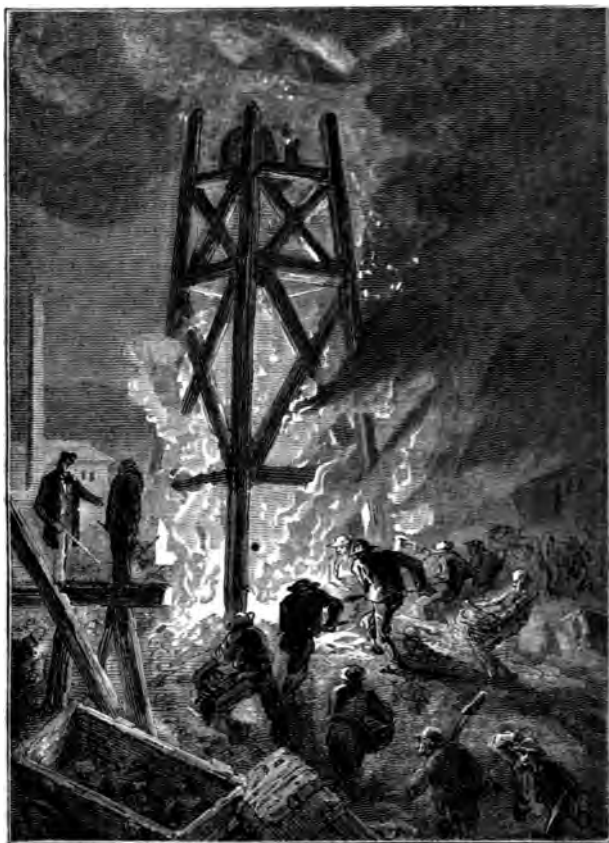
and labour with a persistency and a perseverance which are generally successful.

The heat is overwhelming: the air is vitiated by the products of combustion, and the necessary barriers can be erected only at the cost of indescribable suffering. Not infrequently the workmen are prostrated by the influence of the deleterious gases, and they endeavour to neutralize their effects by applying to the mouth a linen cloth steeped in ammoniac. In this awful furnace they hastily throw up the rampart of clay, while the fire, labouring away in the recesses of the galleries, makes every moment a swift progress, and advances with the rapidity of a flood which sweeps away all obstacles.

We will suppose that the flames are everywhere triumphant, and that man retires from the unequal strife. The coal-pit becomes a perpetual furnace. There are mines which have been burning underground for centuries; as, for instance, Decazeville and Commeny, in France.

Coal disengages from its fissures a combustible gas, protocarburetted hydrogen, which burns with a livid flame,—silently if it is pure, but detonating with a terrible din if mixed with atmospheric air. When it is evolved from the walls of the subterranean galleries, when it is combined with their close and vitiated air, a spark suffices to transform the coal-mine into a powder-store which, in its explosion, shatters a geological stratum, and involves tens and hundreds of unfortunate victims in one common ruin!

When the “fire-damp” (as the miners call it) ignites, a terrible report is heard; the men at work beneath the



FIRE AT THE ASTLEY PIT, NEAR MANCHESTER.

surface are blinded, hurled to a distance, and crushed out of all human semblance by the falling rocks. The disaster is awful in its suddenness ; it is a swift death, which

prostrates its victims before they have time even to think of safety. But, in fact, safety is an impossibility; and when once the explosion has taken place, it is no longer men, or men and women and children, whom we extricate from the subterranean chaos, but torn and shapeless fragments of flesh, carbonized corpses, and mutilated bones, such as we are accustomed to exhume from forgotten graves, where they have lain for centuries! However large the number of the workers overtaken by the scourge, it does not spare ONE; it is as impartial as it is pitiless. For those who may have escaped the direct effects of the explosion are suffocated by the deleterious gases which it generates, or they are burned and charred by fire, or drowned by the loosened waters, or crushed beneath the shattered walls and barriers.

We shall experience no difficulty in selecting a pathetic narrative from the long and dreary record of calamities produced by fire-damp. All are so horrible, all are so full of touching and impressive details, that any story taken haphazard from a thousand tragedies cannot fail to convey an accurate idea of the nature of the disaster.

Let us transport ourselves in imagination, says M. Tissandier, to the coal-mine of Mons, near Saint-Etienne.

It is night. The overseer, with three men, has just descended into the mine, where they find the hostler grooming his horses, and the carpenters repairing the wooden galleries. Suddenly a deafening report shatters the works in every direction; the shaft is transformed into a formidable piece of artillery, which vomits into the air stones and pieces of timber, and with so much force as to hurl them to the astonishing height of three hundred feet. Beams and



EXPLOSION OF FIRE-DAMP.

cables are launched into space by this volcano. The engineer arrives terrified; and, it must be owned, the spectacle is enough to confuse him. Just now everything was calm and tranquil; toil, life, movement, activity prevailed around the mine. In a second the scene is changed; all is death and desolation. And what has become of the poor wretches who were working beneath the surface?

A forlorn hope is hastily organized. The courageous volunteers descend the shaft, but their lamps flicker and go out. An ominous presage! The rescuers, like their lamps, waver and fall suffocated. Two heroes have devoted themselves to save their fellows; soon they are two corpses! An ambulance is established at the mouth of the shaft, and the remaining volunteers redescend. Miners are not niggardly of their lives to save their brethren when in peril; to the last man all would join in the dangerous enterprise; all, if need be, would devote themselves, would sacrifice themselves, and join, with that fierce delight which such devotedness always inspires, the dead lying down *there*, in the darkness and awful silence of the depths!

All night the rescue-party explored the subterranean galleries. Each miner sounded the soil, interrogated the black walls, called aloud upon his lost companions, though no voice was heard in reply. Every moment he expected to stumble against a corpse.

Round the mouth of the shaft gathered a weeping and restless crowd. Wives who knew they were widows, children who felt they were fatherless, waited with strangely blended feelings of expectation and hopeless dismay. One young woman who carried an infant in her arms was the overseer's wife. She did not cease to weep, and again and again she supplicated the engineer for permission to penetrate into the mine and recover her husband; but women were expressly prohibited from entering the pits. Soon she learned the sad intelligence that her husband was dead like the others. Poor creature! she went mad through despair. For several months she wandered about the countryside, asking of every passer-by if he had seen the father of her children, until death released her from her sufferings.

On this occasion the victims of the fire-damp were counted by



MINERS SUFFOCATED BY CHOKE-DAMP.

hundreds. The memory of the overseer's wife is still preserved in the district, and the old miners of Saint-Etienne will still relate to you her touching story.

It is painful to reflect that these catastrophes are nearly always the consequence of the most inexcusable neglect; for miners are provided with lamps so constructed as not to ignite the explosive liquid formed by the combination of atmospheric air and protocarburetted hydrogen. For the invention of these "safety lamps," as they are appropriately called, we are indebted to the humane genius of Sir Humphrey Davy; though it must not be forgotten that a similar lamp, much used in the north of England, was simultaneously invented by George Stephenson, the engineer.

The flame is surrounded by a metallic tube, which, owing to its "calorific conductivity," sufficiently cools the combustible gases that traverse it, to prevent their ignition.

These lamps, however, give but a feeble light; and though they are generally closed with padlocks, the imprudent miners force them open in order to increase the brilliancy of the flame. A moment of forgetfulness suffices to ignite the terrible fire-damp, if it should chance to be escaping from the fissures of the coal.



THE DAVY SAFETY-LAMP.

Our record of the miner's perils is not yet closed. Landslips and floodings are not less fatal than conflagra-

grations and explosions. The supports and frameworks of timber or masonry, which sustain the subterranean galleries, sometimes sink under the continued and enormous pressure. and the miner is imprisoned in the consequent ruin, without any prospect of effecting his escape, unless help come from above. The accidents resulting from landslips have assumed too much the character of legends ; but facts which are really authentic seem almost fabulous. Who has not read the story of the unfortunate Giraud in 1854 ? Giraud was working at the bottom of the shaft of a mine near Lyons. The upper strata gave way, and he found himself imprisoned with one of his companions in a small cavity deep down beneath the surface. How were these poor miners to be saved ? All that could be done was to sink a new shaft in the neighbourhood of the old one, and afterwards carry a gallery through to the point where the accident had taken place. In spite of the ardent exertions of the men engaged in this laborious task, a month was occupied in the necessary operations ; for several landslips occurred to impede and delay them. Giraud and his companion, meanwhile, could hear the sound of the pickaxe ; they replied to the questions of the workers ; every moment they thought the hour of deliverance was at hand. Vain hope ! Giraud's companion succumbed. Hunger and anguish prevailed over him as in the gloomy story of Dante's Ugolino.

Giraud, naturally stronger and more energetic, struggled on. His friend's dead body, lying right across him, corrupted the little air he had to breathe in ; but the desire to live triumphed. Neither hunger nor the

horror of his situation overcame him ; he would not die. For a whole month he fought against death. He did not lose his vital powers, but replied distinctly to every question addressed to him. It is not too much to say that all France—nay, all Europe—watched this fierce struggle, day by day, with the liveliest interest. Every evening was published a bulletin of the day's work, and on the thirtieth day a cry of victory was raised. Giraud was saved. Pale, withered, reduced to a skeleton, his body was one complete sore. Gangrene had attacked every limb ; the cause of it being the putrid corpse which had rotted beside him. He was immediately removed to the hospital at Lyons, where science exerted all its efforts for his relief ; but he gradually sank, and literally faded away.

How many tragedies are also caused by subterranean inundations ! How many disasters are due to the torrents of water which break down the barriers and embankments, and flood the galleries of the coal-pits ! For ages the water has accumulated at the bottom of the mines, and gradually formed immense lakes or basins, which the miner surrounds with dikes of cement and clay, or shuts up in stout timber framework. But if the pressure become too heavy for the resistant force, the dike is broken down ; the water rushes forth with indescribable violence ; and before the miners have time to think of flight, their dead bodies are swept onward by the impetuous stream.

In many mines ancient excavations exist, the remains of the workings of former generations ; their extent and

their exact situation are frequently unknown. These caverns, dug by the labour of man, become the vast reservoirs of the pluvial waters, which slowly but surely fill them. As they carry their galleries through the carboniferous deposit, the miners unwittingly open up a path to these accumulated masses of water; and when the slender partition ceases to offer a sufficient resistance, the water breaks through it, and dashes headlong like an avalanche.

In the annals of mining we read of the terrible inundation which devastated a coal-pit in the department of the Gard six or seven years ago.

The waters of the river Cèze, which flows in the immediate neighbourhood of the coal-pits of Lalle, had suddenly risen during the prevalence of a violent storm; they had overflowed their bed, and precipitated themselves in destructive floods through all the countryside. Hour by hour the deluge spread further abroad, and, before long, it whirled, and eddied, and boiled above the mines of Lalle. A long fissure opened up in the soil, and the waters pouring into this natural gulf, invaded the subterranean galleries. An awful roar was reverberated through the various excavations of the mine; but the cries of one hundred and thirty-nine miners rose above it. The engineer and manager hastened to the mouth of the pit, and, with twenty-nine workmen, succeeded in effecting their escape. But one hundred and ten miners remained below. The question arose, How could succour be conveyed to them, and would it reach them in time to save any lives?

An embankment to keep back the waters was hastily constructed, and twenty-four hours after the occurrence of the accident a young man volunteered to descend into the pit. He struck repeatedly against the walls of coal, and fancied he heard some distant blows in reply to his rude summons. The engineer, M. Parran, has put on record in the *Bulletin de la Société de l'Industrie Minérale*, a very

pathetic narrative of the incidents which followed, and described very feelingly the feverish emotion with which he watched each phase of the painful drama. With our ears close against the coal, and holding our breath, we heard, he says, in an agony of overwrought anxiety, some blows, extremely feeble, but rapid and rhythmic; in a word, the *call* of the miners, and we knew it could not be the echoes of our own, because we had struck at regular intervals.

An enormous mass of coal separated them from the prisoners. In ordinary circumstances three months would have been occupied in opening it up; but now it was pierced in three days, so wonderful and so impassioned is the labour of the miner when it is directed towards the rescue of his brethren. On the second day the workers could hear the voices of the prisoners. "We are three in number," they said. At length they were reached. *Then* there were but two: one of these was in a fever, and nearly dead; the other, and younger, was delirious.

When, some days afterwards, they had recovered their strength, they related the tragedy which had been enacted in their gloomy prison. After the inundation, three of them found themselves in an excavation, with the water boiling under their feet. An old man was with them. They durst not stir for fear of being precipitated into the abyss; and so they waited until death should relieve them from their long agony. On the second day, their aged companion, devoured by thirst, exhausted with fatigue and emotion, stooped down to drink;—he fell without saying a word, and was seen no more! The dense air and the darkness concealed the frightful spectacle from the two survivors. They heard the encouraging shouts of their saviours, and the blows of the pickaxe which was bringing them safety; but they were almost too weak to be glad. One of them wished to drink; he leaned forward to reach the water which rose to his feet; he applied his lips to the liquid, and his mouth touched the dead body of his missing companion!

We close this chapter with a few eloquent but melancholy statistics.

It is computed that about one thousand lives are lost annually by accidents in coal-mines.

In 1858, by *explosions* in coal-mines, 52 persons perished at Bardsley; 20 at Daffryn, near Newport; 52 at Tyldesley, near Leeds; and about 36 in different parts of the country.

On April 5, 1859, 26 lives were lost at the Chain Colliery, near Neath, through the *irruption of water*.

In 1860, 76 lives were lost on March 2, at Burradon, near Killylingworth; 145 at the Risca mine, near Newport, on December 1; and 22 at the Helton mine, Northumberland, December 20.

On June 11, 1861, 21 lives were lost *through an inundation* in the Claycross mines, Derbyshire.

In 1862, 47 lives were lost at Cethin mine, Merthyr-Tydvil, on February 19; at Walker, near Newcastle, 15 lives, November 22; at Edmund's Main, near Bardsley, 60 lives, December 8.

In 1863, 13 lives were lost at Coxbridge, near Newcastle, March 6; 39 lives at Merigam, South Wales, October 17; 14 lives at Moestig, South Wales, December 26.

At the Hartley coal-mine, in Northumberland, on January 6, 1862, a beam at the mouth of the ventilating shaft gave way, and a mass of iron, weighing about 12 tons, fell down the shaft, dividing it, and so blocking it up as to bury alive no fewer than two hundred and two persons, men and boys. Several days elapsed before the bodies could be discovered.

Here we terminate the dreary catalogue to which almost every month adds a new and distressing page.

In numerous localities, we find among the rocks or formations comprehended between the Lower Silurian and the Tertiary, an oily and blackish liquid matter, which burns like coal, and exhibits certain analogies to that precious fuel. This thick oil is the well-known *Petroleum*, also known as "Rock Oil" and "Liquid Coal." Men have long been aware of the existence of the oil-deposits, and they have long utilized them in

Persia, Caucasus, China, and the New World ; yet it is only within the last few years that modern industry has availed itself to any extent of their resources.

At certain seasons of the year, and on the occasion of great public festivals, the port of Bakou, on the frontiers of Persia, and on the shore of the Caspian, presents a very singular aspect : an immense crowd, assembling on the strand, prostrate themselves before mountains of fire which seem to glide along the surface of the waters, and extend far beyond the range of vision, while projecting towards the reddened firmament a myriad coruscating rays, a myriad colossal sheaves and spires of flame.

This scene is due to the mineral oil which the inhabitants have poured out upon the waves : they set fire to it where it floats, and the flame advances rapidly from point to point, until the eye is greeted by the apparent spectacle of an incandescent sea ! The traditions of the country trace back to a wonderfully remote antiquity the origin of this sacred fire, which has its priests, its temples, and its worshippers.

The subterranean deposits of petroleum frequently evolve combustible vapours, which can be turned to advantage on the surface of the soil. Thus, near the port of Bakou, the Parsee fire-worshippers inflame the gases which escape from the earth through orifices bored for the purpose. These orifices are provided with plugs, and when any of the inhabitants are in want of fire to cook their victuals, they uncork, as it were, the little plug-holes, ignite the escaping gas, and profit by this strange natural cooking apparatus. At night, each tiny

orifice launches a luminous jet into the air with a very singular effect ; it acts like a gas-burner, fed from subterranean and inexhaustible sources. These natural fires are used in burning lime and consuming carcasses. The gas which produces them is sometimes collected in vessels, and in this portable form extensively sold. The Parsees trade with it as far as the remotest provinces of Persia ; and their priests make good use of it to maintain the national superstition and keep alive their own influence over the multitude.

In China there are similar wells of petroline vapour : the gas escapes from the brackish springs which abound in the district of Yung-Hian, and the Chinese skilfully conduct it in tubes of bamboo to the places where they wish to utilize it. They employ it in lighting up their workshops and evaporating the salt waters.

At Bristol and Middlesex, in the United States, effluvia of inflammable gas escape from the lakes, and rivers, and fissures of the soil. When the country is covered with snow, when a thick crust of ice rests upon the waters everywhere, no more imposing spectacle can be conceived than that of the combustion of the petroline vapours : the flame, carried onward by the breeze, glides over the surface of the ice ; it floats along the snowy plains ; it springs aloft in luminous gerbs ; and the observer cannot restrain his emotion as he gazes on this magnificent natural illumination.

The ancients were acquainted with some of these

springs, but the ignition of the vapours of mineral oils naturally appeared to them an inexplicable phenomenon. Pliny speaks with wonder of the natural fires of Mount Chimæra, in Asia Minor, and evidently is filled with astonishment while describing the spectacle witnessed by some daring voyagers.

What, indeed, *is* the origin of these liquid combustibles? What mysterious chemical reaction has generated them in the bowels of the earth, and what substance is it which Nature has distilled to form them in her great subterranean laboratory?

The analogy in composition between petroleum and the oils resulting from the distillation of coal leads the geologist to conclude that coal is the source of the mineral oils. And, in fact, it is obviously possible and probable that masses of fossil coal, heated in the depths of the earth, by the central furnace, and always incandescent, may disengage incessant volumes of vapour, whose condensation takes place in the upper crevasses or caverns.

Various modes of working petroleum are adopted. At Rangoon, in the Burman Empire, shafts are bored to a depth of from two to three hundred feet, and consolidated by timber scaffolding. A vessel of pottery-ware is let down the shaft by a rope running through a pulley. As soon as it is filled, it is hauled up, and its contents poured into a reservoir dug in the earth: the water mixed with the oil settles at the bottom, and the oil floats on the surface. The latter is then strained off when wanted. In all the oil-regions, the liquid mineral

soaks the earth and the very stones ; percolates everywhere ; and everywhere seems inexhaustible. Such is not the case, however, and the well, after a while, runs dry.

We turn to America. Here, as a rule, the oil is found collected in fissures of the rocks, which are generally vertical, and it is drawn off through Artesian borings. These vary greatly in depth : sometimes the liquid is found at fifty feet ; sometimes, on the other hand, the well must be sunk to a depth of 300 or 350 feet. Once the deposit is reached, a steam-pump draws the liquid to the surface of the soil ; unless, as in many instances, it comes up by its own force, like a jet of water.

The veins of oil are capricious, and the well-borer is compelled to invent a thousand novel processes in order to "strike" them. Generally the proximity of a vein is indicated by débris of blue clay, soft and viscous, and saturated with an oily, reddish liquid. When the petroleum-seeker, says a writer in the *Toronto Globe*, comes upon these unmistakable signs, he abandons himself to transports of joy, and with a beaming countenance, which radiates with oil and perspiration, he cries enthusiastically, "How fine this is !" And it is fine, if you have an interest in the well which leads you to think of profits to come ; but, in the contrary case, it certainly is not fine, so far as regards the smell and the sight. The well-sinker is joyous, for the oil is worth five or six cents the quart, with a prospect of being worth twice as much. Is not this enough to account for his satisfaction ?

The oil-springs, however, are remarkable for th

filthiness ; and from the four cardinal points the noises of the pedals which set in motion the boring-apparatus are heard throughout the night.

Every day, says the writer already quoted, sees the number of mud-stained travellers increase, who, with wallet on their backs, have waded through the mire, climbed the prostrate trees, and crossed the ditches, on the roads, as yet but barely traced, from Wyoming and Florence. Many come in quest of an occupation which they are sure to find ; others, their pockets filled with dollars, intend to sink new wells, and increase the number of those already in existence.

The yield of different wells is extraordinarily variable. Some produce only from 10 to 12 barrels of petroleum per day. At Idiona, in 1861, seventeen wells supplied upwards of 40,000 quarts in twenty-four hours, and hurled the liquid with wonderful force to an elevation above the soil of sixty feet. In the Erie County, State of Pennsylvania, a single well has furnished as much as 300 barrels a day. At Mecca, in Ohio, a shaft vomited forth 85,000 barrels in the twenty-four hours.

The petroleum-commerce in the United States, and more particularly in Pennsylvania, has daily assumed a greater development, until the mineral oil has come to be sought with almost as much avidity as gold. The most important discoveries, however, were made as far back as 1860 to 1862, and it was especially in the Ennis-killen district that they proved as rapid as they were valuable. In the history of petroleum, as in that of gold, curious examples are found of sudden favours of

Fortune, and of the elevation of paupers to a position of extraordinary opulence.

In 1862, a modest American operative, named Shaw, made an important discovery of mineral oil. The history of this unfortunate man is too popular in America, too interesting, and too instructive for us to pass it over without notice.

His sudden elevation from poverty to wealth, and his tragic end, might furnish the themes of a stirring romance: for, whatever moralists may urge, romance is not dead. If it is not so popular in the library as it was wont to be, we cannot deny that it is daily developed around us

If, at the beginning of the year 1862, you had been travelling near Victoria, in the district of Enniskillen, you could not fail to have been impressed by the strange aspect of the country: numerous wells whence was extracted the black, noisome oil; dreary expanses of mud; pools of mineral oil in every direction; workmen black and greasy, and covered with oil; sign-posts with conspicuous lettering, "Smoking is Forbidden Here;" all would have reminded you that everything round about was combustible, and that a match, incautiously dropped, might envelop the whole country in flames.

Upon lot 18, in the second concession or section of Enniskillen, you would have seen the well belonging to John Shaw, in which he had sunk all his hopes.

John Shaw had worked from his birth; he was working still; he would work, if need be, to his grave; but Fortune frowned upon him.

From morning to evening, he dug slowly and laboriously, and carried his shaft down deeper and deeper. He pumped incessantly, but the oil did not rise. Next day, he dug and pumped again. So time went on: he spent all his money, and lost all his credit. He exhausted his strength; he ruined his health by his unrelaxing industry; yet not one drop of oil came to reward him for his toil. While the wells of his neighbours yielded abundantly, and flowed with gold, John Shaw alone could not "strike" the subterranean current of petroleum. The unfortunate man was soon at the end of his resources, and his unsympathetic neighbours, far from

pitying, mocked at him : his pockets were empty, his clothes in tatters ; he was ruined, utterly broken, and for ever lost. It is even said that his worn and tattered boots would no longer hold to his feet, and that he was compelled to suspend his work for want of new shoes in which to tramp about in the oil and mud.

Desperate, beaten, timid and shamefaced like Misery, he went humbly to a bootmaker, and besought him to let him have a pair of boots on credit. An insolent refusal was all he obtained, and the wealthy tradesman poured out his contempt upon old Shaw, who, according to an American expression, was not worth "a pair of boots !"

The poor well-sinker returned to his hut, thoroughly overcome, and the victim of despair. He resolved that on the morrow he would make a final effort ; would strike one last stroke, and essay one last pull at the pump ! If no oil came, he would leave that land of bitterness, and endeavour to gain a more favourable region. He lay down, spent and weary, but he could not sleep. At day-break he snatched up his boring-tool, and dealt a blow at the rock with all the energy of despair. All at once he imagined that he heard the bubbling of the liquid. It was no delusion ! He could hear the oil hissing and bubbling as it rose, the petroleum as it escaped from its secular prison !

The current increased ; the liquid mounted and dashed headlong like a deluge ; it roared like a tempest ; it filled the tube ; it overflowed the shaft ; it rose, and still it rose, always irresistible and always formidable. Five minutes passed, ten minutes, a quarter of an hour ; still the current mounted upwards ; an awful, formidable roar was heard ; an impetuous torrent leaped from the pit like a volcano ; the oil poured out, and poured over an enormous reservoir, and resisting all the efforts made to arrest its course, invaded the canals, spread over the soil like a flood, as far as Black Creek, where it mingled with the waters and was carried onwards to the Lakes and the Saint-Clair.

It is impossible to describe the feelings of John Shaw at this unexpected reverse of fortune. The stupified spectators have not put upon record whether he danced with joy, or shed tears of happiness. It is affirmed, however, that he raised his hat with feverish enthusiasm, and shouted "Hurrah !" with all the force of his lungs.

To extravagant demonstrations, however, he did not long abandon himself. Like a philosophic Yankee, who can take Fortune's smiles as coolly as he takes her frowns, he hastened to store up his oil, and set to work to check the too impetuous torrent. The roar of the leaping liquid attracted all his neighbours. Everybody hastened to congratulate the intelligent operative, whom they no longer called Father John, but respectfully saluted as "*Mr. Shaw.*" Felicitations were rained upon him, and while covered with mud and streaming with oil, he proudly stood erect beside his well, the tradesman who had refused the pair of boots arrived. He had learned the change in Shaw's prospects, and hastened to bow before the rising sun, before the man of wealth.

"My dear Mr. Shaw," said he, "it was quite by mistake that I refused your request yesterday. In fact, I did not clearly comprehend your proposal; but if my warerooms contain anything suitable for you, they are entirely at your disposal."

What a triumph for Shaw! What a moment of happiness! However, his reply we need not put upon record, as it was more distinguished by energy than by politeness.

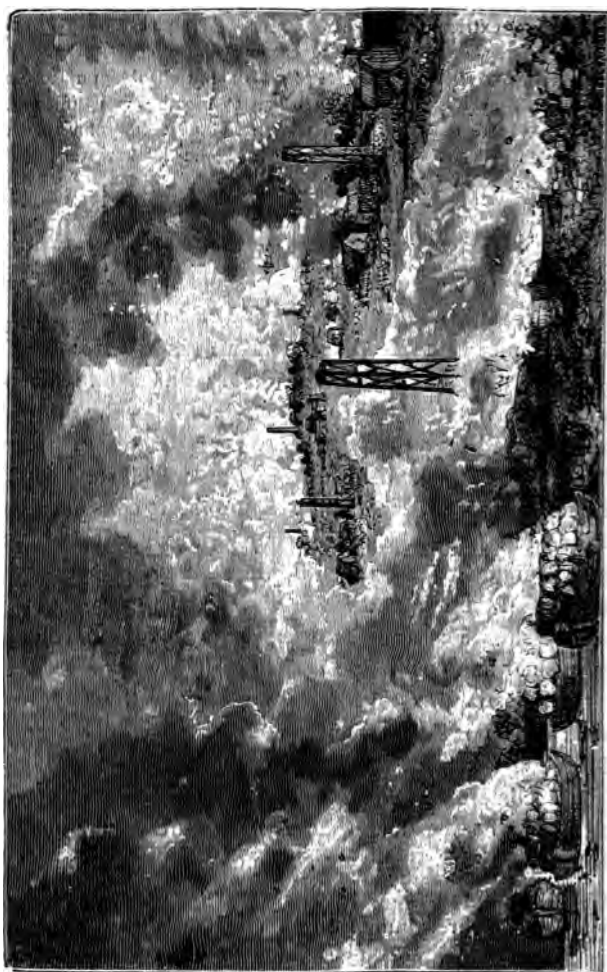
The well continued to flow with extraordinary abundance, and Shaw proceeded to calculate the outcome. He saw that it produced two barrels of 180 quarts each in a minute and a half, which, at the then price of petroleum, was equal to a profit of half-a-crown a minute, or £7, 10s. per hour; that is, £180 per diem, or about £65,000 per annum, if we include Sundays. The *Toronto Globe*, from which we borrow this extraordinary narrative, justly remarks:—"Neither the celebrated authors of the 'Arabian Nights' Entertainments,' nor even Alexander Dumas, could have imagined a transformation so sudden as that of John Shaw: in the evening a beggar, in the morning he is a millionaire, able to satisfy the wildest imaginations, and to indulge himself in whatever luxury money can purchase!"

The unfortunate Shaw, however, did not long profit by the favours of Fortune. Rich and celebrated, he was soon to die in a singularly horrible manner. A year after the happy event which we have recorded, he descended about fifteen feet into his well to

withdraw or extricate **one end** of the tube. He placed his foot in a **kind of stirrup**, and clung to the extremity of a chain. After he **had reached the tube**, he signalled for his men to haul him up to the **surface**. They observed that he began to breathe with difficulty, and made haste to wind up the chain. Too late ! John Shaw, overcome by the effluvia, relaxed his hold ; he fell backward, and disappeared for ever in the gulf of oil !

The working of the mineral oil, like that of coal, is sometimes attended with very serious danger, and its history is darkened by some terrible catastrophes. Thus, for example, wide-spreading conflagrations have destroyed in a few hours the labour of a whole year. Nothing can well be more frightful than the combustion of the oil-pits accumulated over a district of considerable extent. The flame, like a devastating scourge, irresistible as a deluge, rushes onward with incredible rapidity. It consumes, in an instant, houses, granaries, churches, public buildings ; it devours everything which lies in its track ; it burns the mines and the miners ; and leaves a black desert of ashes on the site where a few hours before a prosperous colony flourished in industrial peace.

In the month of April 1862, while a well was being sunk at Idiona, in Pennsylvania, a current of oil suddenly leaped to a height of forty feet above the ground. This liquid column roared in the midst of a dense cloud of fetid and combustible vapours. The fires in the neighbourhood were extinguished immediately, yet not so rapidly as to prevent disaster. One lingering fire, situated upwards of three hundred and fifty yards from the well, ignited the combustible column, which had sprung so fortuitously from the bowels of the earth, and the whole



CONFLAGRATION OF PETROLEUM AT IDIONA.

atmosphere was soon on fire. The mass of oil leaped up in sheaves of flame, and incandescent streams poured rapidly into the fields. The workmen fled pell-mell, with loud cries of alarm and horror. The sky grew red above the scene of conflagration ; here and there, the oil-casks, lying on the ground, gave way and exploded, like the peals of a heavy cannonade.

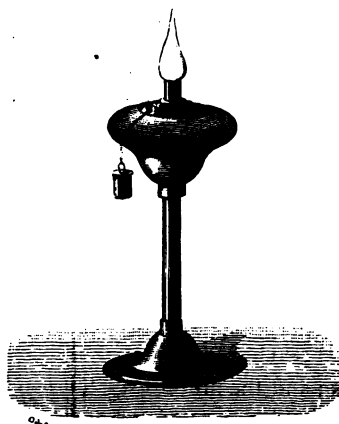
In the midst of this indescribable horror, dead bodies, dismembered, were hurled on high ; women and children, sorely burned, struggled to escape from the fiery hell ; they seemed like so many phantoms, lit up by a supernatural glare !

The flames spread wider and wider, and rose higher and higher, as if they would reach the clouds ; the explosions grew more numerous ; and the fire propagated itself with the swiftness of the hurricane. It was useless to think of resisting a force so invincible. Nothing could be done but to wait in gloomy patience until the last drop of oil was consumed.

Oftentimes similar scenes, in the United States, have spread terror over wide and thickly populated districts ; and, unfortunately, terrible catastrophes have desolated too frequently the most prosperous parts of Europe. The conflagration of Bordeaux, when thirty ships were destroyed, will probably be remembered by many of our readers. Such instances illustrate only too forcibly the dangerous nature of the mineral oils, and we may well grow indignant at the guilty negligence which causes, or does not prevent, such awful disasters.

Petroleum has been successfully employed for the pur-

poses of lighting. The most volatile essence which it gives off in distillation is employed in the oil-less lamp



THE OIL-LESS PETROLEUM LAMP.

(*lampe sans huile*), where it is absorbed by a sponge, and burns in a state of vapour. The ordinary lamp is too well known to need description. It is quite possible that petroleum may also be made useful as a fuel; and ingenious minds, both in Europe and America, have long occupied themselves with this problem, especially with a view to rendering

it available for steam-engines. This question, less generally understood than that of lighting, is much too interesting for us to pass it over in silence. The advantages presented by the liquid coal are easily indicated: it burns without any residuum of ashes; owing to its fluidity, it would flow spontaneously into the furnace, doing away with the toilsome occupation of the stoker, and avoiding the loss of heat caused by the occasional opening of the furnace-door. Coal, moreover, occupies a considerable space, on account of the intervals necessarily occurring between the different blocks. A ton of coal forms a more considerable mass of fuel than a ton of mineral oil. Now, in locomotive engines, and more especially on board steam-ships, space is precious.

These, however, are not all the advantages of petroleum : a ton of this liquid produces by combustion twice as much heat as a ton of coal. A vessel loaded with petroleum as a fuel would be able, therefore, to accomplish a voyage



THE ORDINARY PETROLEUM LAMP.

of twice the length which would be possible if she carried the same weight of coal.

It is now some years ago since serious attempts were first made to employ it as a combustible in the furnaces

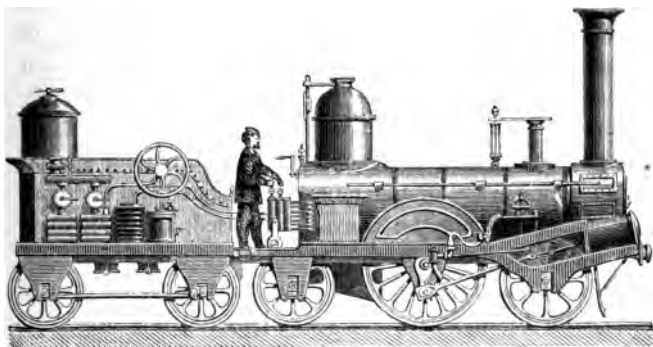
of steam-engines. Our engineers at Woolwich attempted, at the outset, to make it burn on the surface of a porous vessel ; but this system was attended with the grave defect of not sufficiently separating the furnace from the reservoir, and of rendering imminent a terrible explosion.

Afterwards, at Lambeth, the liquid was injected, through the agency of superheated vapour, into an ordinary furnace ; but it was found that this process gave rise to a very considerable loss of heat.

The experiments made more recently in America have led to more satisfactory results, not only in the case of stationary engines, such as are used in our manufactories and works, but also of fire-engines, and on board steam-vessels. A great fire at Boston was rapidly subdued by means of fire-engines set in motion by petroleum. In a few minutes, the pressure obtained was sufficient to fling enormous volumes of water on the burning houses ; and the success of this first essay decided the municipal authorities to provide other apparatus of a similar construction.

For some time, a large number of stationary engines, and even of locomotives, have been heated by petroleum, in those parts of the United States and Canada, where the mineral oil abounds. Its economy is manifest in regions where the combustible liquid flows in all directions, and coal is wanting. In July 1867, a locomotive, supplied with petroleum, ran upon the railway from Warren to Franklin : it traversed the entire county of Venango, a district covered with oil-wells, and successfully arrived at its destination. The petroleum was burned like gas,

being allowed to escape from a small burner : the grating of the furnace was replaced by a cast-iron basin, on which were set six heaters (*réchauffeurs*) performing the function of gas-generators. The oil was conveyed into these heaters in a gaseous state, and burned at the extremity of the burner situated under each. The flame not only heated the boiler, but served also to distil the petroleum. One must go to America, and its oil region, to see men thus playing and sporting with fire ; for the



A LOCOMOTIVE HEATED BY PETROLEUM.

dangers of such a system are evident. But what cares the reckless Yankee ? So long as his machinery performs its rapid task, he has no time or inclination to think of explosions !

Shortly after these attempts, Colonel Foote organized a new system on board the United States war-ship the *Pallas*. He placed the distilling apparatus of the petroleum at a great distance from the furnace, so as to do away with all risk of explosion. The vapours, carried

through conducting tubes, burned in the furnace of the machine. A powerful air-pump forced into it, on the one hand, the combustible gas, and, on the other, the air necessary for its combustion. An official commission was present when the new process was tested, and after very careful and minute experiments, decided that the use of mineral oil was most successful on the point of economy. New essays have been made in California, with mineral oils extracted from the schists of Santa Cruz, burned in an apparatus resembling the preceding. According to the San Francisco *Morning Call* (October 1867), a ton of this oil gave the same amount of motive force as ten tons of the best Cardiff coal! This is an obvious exaggeration. Yet we may say with a French writer :—"Mineral oils are a dangerous combustible, and require special precautions ; but in apparatus well designed and well constructed, they may be conveniently used, and they burn without producing smoke. With an equality of weight and volume, they give forth an amount of caloric greatly superior to that which is yielded by the best kinds of coal."

As petroleum burns without smoke, a steam-vessel supplied with it furnishes a singular spectacle. One is so accustomed to see a steamer drag in her wake a black, dense cloud, elongated in the atmosphere like a gigantic pennon, that it seems as if some mysterious force set in motion the wheels which cleave and churn the waters, though no visible vapour escapes from the funnel. We may remark that this fact is of some importance so far as war-ships are concerned ; for henceforth, thanks to petro-

leum, they may bear down upon an enemy without throwing abroad upon the heavens that black and dreary signal which now betrays their approach long before they themselves are in sight.

But we see that these American experiments, interesting as they may be, are without that definiteness and precision essential to the determination of an authentic estimate of their value. This uncertainty has led M. H. Sainte-Claire-Deville to measure, by a practical method, the quantity of heat yielded by each kind of mineral oil, and to seek the best mode of construction for an apparatus of combustion. From his very careful researches it appears certain that two pounds three ounces of raw Pennsylvanian petroleum will evaporate thirty-three pounds of water nearly ; a fact which proves that the calorific power of mineral oil is double that of Cardiff coal.

The apparatus invented by M. Deville differs from that of Colonel Foote in this direction, that the combustible liquid, undistilled, burns in its liquid state, flowing along the door of the furnace, which is really a vertical grating. The boiler, thus arranged, permits the alternative combustion of oil or coal. If it is desired to pass from one system to another, all that has to be done is to replace the refractory plate by an ordinary grating ; and the cast-iron perforated plate, which affords a passage to the oil, by the ordinary door of the coal furnace. It is, in our opinion, very important to regard the problem from this double view-point, for the utility of being able to replace one system by another in transoceanic navigation is very obvious. Europe is not very rich in mineral oils, and

to observe the law of economy, which is or should be the basis of industrial operations, those vessels which sail between Europe and North America might consume coal on their outward voyage, and petroleum on their return. We must not forget that mineral oil, which costs about three shillings per hundredweight at Oil Creek, will fetch twenty-five shillings at Southampton.

An immense future is opened up to Steam Navigation by the employment of petroleum. Here we are led to dwell on a curious observation of M. Deville's. We know that the combustion of hydrogenated bodies produces water ; that coal gas, for instance, when burning, furnishes a certain quantity of humidity to the atmosphere.

Well, by burning mineral oil in the furnace of a ship, we produce, by synthesis, water, which it is possible to collect and condense. The water thus generated is pure, and exempt from all mineral corruption. It can be employed to supply a steam-boiler without any fear of its depositing, by its evaporation, those saline matters which form such troublesome and, sometimes, dangerous incrustations. Here, then, a new horizon opens up to science, a new horizon, and, as recent experiments on board the *Puebla* at Boulogne give us good reason to hope, by no means an impossible or imaginary one.

The experiments to which we refer have resulted also in the demonstration of some unexpected facts of great interest to a maritime nation. They have shown that the holds of ships might be kept perfectly fresh, though now they are little better than pestiferous ovens, in which the unfortunate engineers are almost suffocated ; they have

shown it to be possible to do away with the funnel, which rises above the deck of the ship, and by the new system of heating, in which compressed air is employed, the funnel can be made to open beneath the surface of the water.

But then, if the funnel may safely communicate with the sea, if the hold of the ship is no longer kept at a high temperature, may we not expect the almost complete creation of the monster which has already sprung from American ingenuity?—that submarine vessel, that terrible monster, which, submerged in the depths of the sea, will cleave the liquid element, and, after the manner of the huge cetaceans, hide beneath the wave, when the hurricane and the tempest are sweeping on in their destructive course?

THE PRESENT AND THE FUTURE.

We have seen that the annual production of coal, in the whole world, may be estimated at two hundred millions of tons. What do we not obtain from these two hundred millions in heat; that is to say, in motive force: in illuminating gas; that is to say, in light: and in ammonial salts, dyes, bitumen, asphaltes, and other substances of very considerable value? These two hundred millions of coal yield six millions of tons of coal tar; this residuum alone is sufficient for the manufacture of five hundred and fifty tons of violet or aniline dye, representing a sum of £1,200,000. May we not say that industry transforms coal into the precious metals, and metamorphoses it into inestimable riches?

Steam, now-a-days, is the principal source of the wealth of civilization; and coal is the fuel which, at the lowest cost, yields the greatest quantity of steam. Every day

increases the number of machines set in motion by coal; every day, therefore, increases its importance. It is the very life-spring of the prosperity and greatness of England; and the exhaustion of our coal-fields will be synonymous with the extinction of our imperial power.

The following remarks of M. Tissandier will be read with interest, as bearing upon a subject of so much importance :—

“It may be admitted that coal is the food of industry. But abundant as are its deposits, and dense as are its masses, will not the day arrive when they will be exhausted? What spring does not dry up? And will our supply of motive force, our riches, and our civilizing fertility perish when the coal-fields cease to produce? Will industry perish on losing its daily nutriment? Has nothing occurred to disquiet us in reference to the future reserved for our descendants? Is there good reason to fear that human activity will one day become extinct for want of the earth's black fuel?

“The duration of the working of the coal-fields, which geologists fixed at first at tens of thousands of years, will not, in all probability, exceed five or six centuries.

“It has been demonstrated by official statistics that the consumption of coal, in a civilized country, doubles every fifteen years; and this law of progression holds good, at all events, in France, as is shown by the subjoined figures, which we borrow from M. Burat :—

Years.	Totals of Extraction in Quintals.
1815.....	9,500,000
1830.....	18,000,000
1843.....	37,000,000
1859.....	75,000,000

"The same economic phenomenon occurs in the other centres of production. Belgium produced thirty-six million quintals of coal in 1845, and seventy-five million, or rather more than double, fifteen years afterwards, in 1860. It is probable that, in the course of centuries, this progression will go on, perceptibly increasing. But let us suppose that it remains constant, and let us endeavour, on the other hand to ascertain, as accurately as possible, the total amount of coal existing in the world, and we shall then have the data necessary for a solution of this problem,—When will the coal-fields be exhausted?"

Our next quotation is from M. Simonin :—

"When," he says, putting to himself and his readers the same question, "will the world's coal-fields be exhausted? The duration of their working," he continues, "which geologists, as we know, fixed at first for tens of thousands of years, though their calculations applied only to one-fourth of those now known to man, will not exceed, perhaps, five or six hundred years. We may even assert very positively that in countries where the coal-fields are incessantly worked, as in England, France, Belgium, and Prussia, the subterranean extraction of the mineral combustible will not be possible for half that time. Sir William Armstrong, some years ago demonstrated that in two centuries all the coal-basins of the United Kingdom would be entirely exhausted. Sir Roderick Murchison afterwards made a corresponding statement." *

* Recent official inquiries, however, have shown that our condition is not so deplorably bad. Assuming that the present rate of consumption is not largely exceeded, it would appear that we have coal sufficient to supply us for seven or eight centuries.

At the utmost we may not do more than double or treble this figure for states like Federal America, where immense deposits remain almost untouched. In Africa, the mineral combustible is far from being widely distributed, except on the west coast of the island of Madagascar. In Hindustan, the Burman Empire, China, Japan, Australia, New Zealand, New Caledonia, Chili, where it has been likewise discovered, frequently over a very considerable area, it will suffice only, except in a few special instances, for local consumption. Moreover, coal, at least when we wish to utilize it for great industrial operations, is not of such value that it will pay for being carried long distances, even by sea.

Must we admit that the total of consumption, in the majority of the European states, will some day diminish, when the completion of their network of railways will necessitate the closing of many of their great manufacturing establishments, and when some other substance will be introduced for the purpose of lighting our streets and houses? But this diminished consumption will never be very great; and will not the increased supply of fuel required for the increasing number of locomotives and steam-ships more than compensate for the diminution? It is useless to speak, as some persons do, of replanting the forests,—of wood one day replacing coal, as the latter took the place of wood. The world does not go back. In some branches of industry, petroleum may furnish a substitute; but this substance will never be so abundant as coal, and, consequently, will be much more speedily exhausted.

The question, says Tissandier, is a threatening one, if not for ourselves, at all events for our descendants ; it stimulates to the highest point the interest of England and Belgium. And the peoples of both countries examine with anxiety their coal-deposits. These countries, says Tissandier—not, we fear, very accurately—begin to work them with economy, so as to defer as long as possible the period of their exhaustion. They utilize the common coal, which they formerly rejected ; they organize ingenious and economical machinery to reduce the cost of working to a minimum ; they seek for means of penetrating into the greatest depths of the coal-fields, that nothing may be thrown away. But all these improvements will not prevent the eventual disappearance of coal, and its return to the atmosphere, its original source, in the state of carbonic acid. The coal-mines, as yet unknown, the oil-springs, however prolific, must disappear ; and we are in the right to ask ourselves, What will become of man when this supreme moment arrives ?

But, for our own part, we do not see why any disquietude should be cherished respecting the future ; for Man, continuing his onward progress, will assuredly survive the extinction of his present supplies of fuel. We cannot doubt but that when the fatal hour shall have sounded, some genius, issuing from the ranks, will know how to fertilize the field of grand discoveries ; and that the forces of nature, wisely turned to advantage, will replace that motive force which we now find in coal.

Who will tell us that the steam-engine is the *ne plus ultra* of science, and that it will not be succeeded by

other and more powerful motors? Does not the sun transmit to us its calorific rays, which may, perhaps, set in motion the pistons of future machines? Is not the sea on our shore subject daily to the movement of the tides, and is not the successive oscillation of its floods a prodigious, a constant, and a regular force, which man may utilize? If it be true that a perpetual fire burns beneath the surface of our globe, may it not one day become the sole furnace of all our machines? Is not the air incessantly in motion above our heads, and does not the wind possess a powerful motive force, always ready to act like a bent spring?

Had it been said, a century ago, that the day would come when slender wires plunged deep in ocean would become the nervous fibres of the continents, by whose aid they would exchange their thoughts; had it been asserted that man, like the bird, would mount aloft in the air, or, with the rapidity of the stag, speed along upon iron ways; had it been declared that the surgeon one day would amputate the limb of a patient while he remained unconscious of the operation, and insensible to its pain;—he who had prophesied such marvels would have been denounced as a madman, and his neighbours would have pitied him for his hopeless insanity!

In like manner, if to-day some gifted spirit could set before us the inventions of our grandsons, when they shall be compelled to dispense with coal; if he could show us all the discoveries of their future industry, possibly we should be unable to refrain from smiling at his enumeration of wonders, and should give no more

credence to his affirmations than to those of the fantastic Micromegas, when he promises men that he will teach them the exact nature of the human soul. We should not fail to assert that the realization of such prodigies was impossible, and should fall into the error of Arago, who ridiculed the idea of railways, and into the imprudence of Napoleon, who condemned steam-vessels. Instead of resorting to incredulous raillery, it would be wiser to remember that the word "impossible" ought to be banished from the vocabulary of human industry, that the error of to-day may be the truth of to-morrow, and that science has frequently transformed the wonder into a fact, and the dream into a reality !

From the report recently issued by the inspectors of mines, it appears that the quantity of coal raised in Great Britain in 1872 amounted to 123,393,853 tons ; an increase of 5,954,603 tons over the quantity raised in 1871. The greatest increase was in the three following districts :—In North and East Lancashire the quantity rose from 7,575,800 tons in 1871 to 9,363,236 tons in 1872 ; in Yorkshire, from 12,801,260 tons to 14,576,000 tons ; and in the Derby, Nottingham, Leicester, and Warwickshire district, from 9,252,900 tons to 10,657,100 tons. The Northumberland, Cumberland, and North Durham district shows an increase from 12,530,000 tons in 1871 to 13,010,000 tons in 1872 ; the South Durham, a decrease from 17,746,000 tons to 17,395,000 tons ; the West Lancashire and North Wales, an increase from 8,775,000 tons to 9,000,000 ; the North Stafford, Cheshire, and Shropshire, a decrease from 6,500,000 tons to 6,327,188 ; the South Stafford and Worcestershire, an increase from 10,500,000 tons to 10,550,000 ; the Monmouth, Gloucester, Somerset, and Devonshire district remains as before at 7,000,000 tons ; the South Wales district shows a large increase, from 9,120,000 tons to 10,131,720 ; East Scotland, an increase from 8,883,920 tons to 9,046,814 tons ; and West Scotland, a decrease from 6,554,365 tons to 6,336,705 tons. About 150 coal-

mines are scattered over other counties of England than those above named, but no estimate of the coal raised by them is given. The production in Ireland is so inconsiderable that it is not included in the computations. The foregoing figures show the result arrived at by each inspector for his own district.

The export of British coal to foreign countries in 1872 exceeded 13,000,000 tons; and above 2,500,000 tons were sent from Great Britain to Ireland; so that the quantity consumed in England and Scotland will be 107,500,000 tons, or about four tons per head, being upwards of 5,500,000 tons more than in 1871.

With respect to the introduction of coal-cutting machinery into our mines, it seems desirable to record that our mine-proprietors have made numerous experiments in furtherance of this desirable object, but hitherto without much success. In 1864 the South Yorkshire Coal-Owners' Association subscribed £500 towards the cost of putting down three machines at as many district pits. Three machines, patented by Mr. G. C. Jones, of the Blama Iron Works, Monmouthshire, were introduced, but after a time withdrawn. In 1867, the members of the South Lancashire and Cheshire Coal Association offered £800 for the best machine. In 1872 Mr. W. Furth, of Leeds, offered £500 for a machine that would *bore or hole* in the most perfect manner, so as to reduce the quantity of manual pick labour to the minimum. It would appear that neither offer produced any great improvement. Another effort is contemplated (December 1873) by the members of the Midland Institute of Mining Engineers, who have appointed a committee to inquire into and report the merits of various coal-cutting machines now in use and patented.

The advantages to be gained by the introduction of good machinery are very important. Economy in the production of the coal, and consequent diminution of cost; and, what is still better, a signal improvement in the moral and social condition of the miners, who, if relieved from the heaviest, most exhausting, and, it may be added, most degrading portion of their work, would be raised in self-respect, and secure more opportunities of availing themselves of the means now placed within their reach of religious and secular instruction.

The Messrs. Baird and Co., of the Gartsherrie Ironworks, near Glasgow, have long been engaged in the perfecting of a coal-cutting

machine, originally designed for them, we believe, by a Mr. Gledhill. In the *Glasgow News* of December 12, 1873, we read that a number of their machines are presently at work in a coal-pit, "No. 3 Espieside," about half a mile from their works. The following description will interest the reader:—

When a visitor arrives at the pit-head, he is taken in charge by the manager, who describes the engines, which are on the double horizontal principle, with steam and air cylinders. Outside the engine-room is a large air-receiver, where the air is compressed to 35 lbs. or 40 lbs. per square inch. Thence it is conveyed down the shaft and along the workings to the machine in cast-iron pipes, with the exception of that portion immediately fitted to the machine, which is an india-rubber tube, so that it may be extended or shortened as the machine moves backwards or forwards along the face of the coal. The machine may thus be briefly described:—The working parts of the machine are carried upon a strong cast-iron sole-plate, 6 feet long by 2 feet 6 inches broad, set upon four wheels. On the sole-plate is bolted the cylinder, which is $8\frac{1}{2}$ inches in diameter, with a 12-inch stroke. The shaft is fixed in bearings cast upon the sole-plate. On this shaft is placed the fly-wheel and eccentric, which is reversible. On that end of the shaft which overhangs the sole-plate is attached a spur-wheel, which, by means of another shaft and bevel gearing, is connected to an upright shaft, and on the under end of which is fixed the chain-wheel, which gives the motion to the cutting chain. The whole of these wheels are made of Bessemer steel, and have proved very satisfactory in their wearing powers. The machine, when at work, draws or "feeds" itself along the coal face, with a "jib" projecting underneath the coal from 2 feet 9 inches up to 4 feet, as required. The cutters, nine in number, and $2\frac{1}{2}$ inches broad on face, are secured to the chain by means of two bolts passing through cutter and link. The jib, which distends the chain, is bolted to the side of the sole-plate, and consists of two parts (the stock and point), adjustable by means of a nut and screw working against a bridge in stock. The chain is made of wrought steel, and the cutters of the best tool steel. It may here be explained that the machine draws or "feeds" itself by means of a drum and a chain passed round a pulley fixed to a prop 100 feet in advance. The drum shaft is moved through a toothed wheel worked

by a ratchet motion from an eccentric cast on the bevel-wheel of the upright shaft. The roadway on which the machine travels is of cast malleable iron. The rails are "keyed" down to sleepers, and are kept in position by means of snugs cast on sleepers, which fit into oblong holes in the end of the rails. By reversing the motion and the cutting tools, the machine travels and cuts in either direction. When at work it is attended by three men, one driving, one lifting the roadway behind the machine, and the other laying down the roadway in front. The "face" along which we saw the machine travelling measured 377 feet in length; and this was completed in one shift, giving a daily output of from 85 to 90 tons from a single machine, in a seam of 2 feet 7 inches high. While sitting in a "cundy" close by the machine in operation, we saw fifteen feet of coal cut in about twelve minutes, with two brief stoppages included. Among the principal savings effected by the machine as compared with hand labour are these,—that it increases from two to threefold the quantity of coal that can be taken by manual undercutting from a given face in a given time, and so lessens the upkeep of roads and the area of supervision and ventilation; while the undercut made by the machine being $2\frac{3}{4}$ inches high, the dross or small coal produced is brought down to a minimum. The great economy, however, is in the *cost* of the undercutting; and no blasting is required after the machine has been brought into proper working condition. But perhaps the most important element in the successful introduction of "Baird's Coal-cutting Machine,"—at least, that which will be most felt by the working-class community,—will be the great relief afforded to the miner in the prosecution of his laborious and dangerous avocation. Undoubtedly, the machine, in its improved condition, will, to a very great extent, relieve him from the most arduous and enervating portion of his labour, while allowing the coalmaster to work, with comparative ease to his workmen and profit to himself, shallow seams of coal hitherto unworkable, either as regards safety to life or fair remuneration for the capital so expended.

CHAPTER VIII.

QUARRIES AND QUARRYMEN.

Mineral industry: its origin—Army of workers employed by it—Quarries and quarrymen—Slate quarries—Quarries of alabaster and marble—Quarries at Volterra—Carrara and its marbles—Roman quarry at Polvaccio—Valley of Ravaccione—The Concha—A visit to the works—The saw-mill—Marble works at Marseilles—Filfila—The Carrarese sculptors—Manufacturers of imitations and copies—Academy of Carrara—Roman quarry at Colonnata—Historical details—The quarries of Paris—Geological description—Gradual formation of the Paris basin—Its present characteristics—Erratic blocks—Occurrence of a great natural revolution—Strata of the Paris basin—Chalk—Clay—Shell limestone—Ancient history of the Parisian quarries—Used as Catacombs—Quarries now at work—Plaster of Paris: what it is—How it is worked—The American quarries and their marls—The Sandstones of Fontainebleau—The workmen of the quarries—An anecdote—A story from Irvy—The "Gouapeurs"—Conclusion.



THE aggregate value of the riches enclosed in the different strata of the globe has originated an industry as old as humanity itself, which is not one of the least of the wonders beneath the surface: we mean the mineral industry. With this department of human labour is connected the development of the mines and stone-quarries; and we have already seen how the prosperity of States depends upon their resources in coal and metal. The working of salterns, of mineral waters, of oil wells, of gaseous springs and the like, has communicated to certain countries a physiognomy peculiarly their own, and greatly augmented their wealth and prosperity.

From the earliest ages of humanity it is the discovery of the value of the subterranean deposits which alone has rendered progress possible, and enabled man to pass from the Age of Stone, as it is called, to the Age of Bronze (or Brass), and thence to the Age of Iron. It is the last cycle which we now are traversing, and the reader knows to what a degree of material civilization we have attained in this period of the Iron Age, which has witnessed the invention of the steam-engine, of railways, of steam-ships, of rifled cannon, of armour-clad ships, and the general development of the iron and steel manufactures. By one of the fatalities of the world, it seems imperative that the arts of war should ever keep pace with those of peace, and that the science of mutual destruction, as Montaigne called it, should march abreast with those gentler sciences whose object it is to efface, or at least to mitigate, the miseries of this life.

Subterranean industry has given birth to a whole army of manly and meritorious workers, who may fitly be called the "soldiers of peace," and who possess over the children of war this supreme advantage: *they* produce, while the latter destroy. We shall have something to say hereafter of the career of these brave pioneers; of its perils, its sufferings, and its anxieties. Unquestionably their life is far more hazardous, as it is far more laborious, than that of the seaman or the soldier.

An important branch of mineral industry to which we may here direct the reader's attention is the working of the quarries. In Europe and America it finds employment for some millions of labourers.



A SLATE-QUARRY.

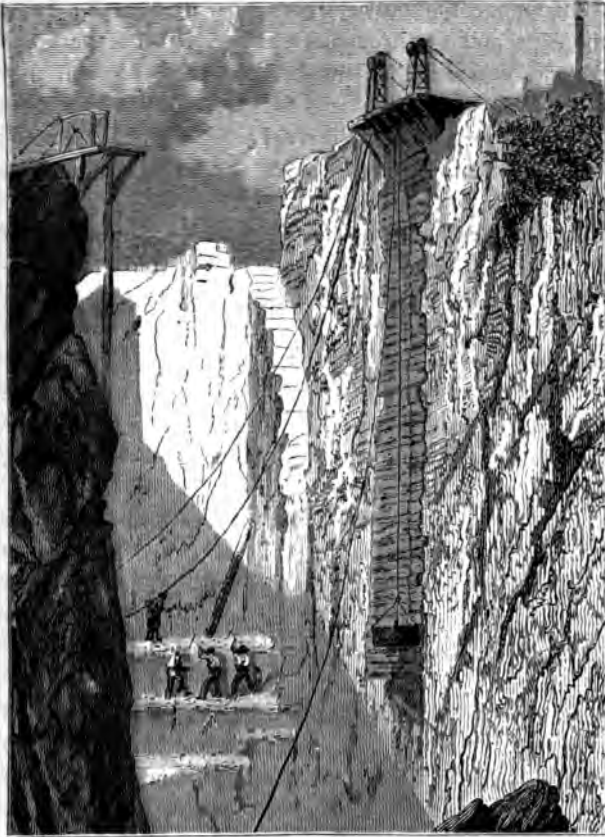
There are quarries of building stone, of stone for lime and cement, of hewn stone, and of paving-stones ; quarries of brick-clay, pottery-clay, and porcelain-clay ; quar-

ries of sand for masonry and glass manufacture ; quarries of slate, mill-stones, alabaster, and marble.

Among the slate-quarries we may mention those of Ballachulish, in Scotland.

Slate, we may observe, is a word with many meanings. It includes mica-slate, composed of quartz and mica, and of a gray or silvery gray colour ; this is used for hearth-stones, flagging, and for lining furnaces : hornblende slate, of the same colour, but deader : talcose slate, containing talc instead of mica, and used for hones and scythe-stones : chloride slate, which is dark green : argillaceous or clay-slate, which is very plentiful in Great Britain, being found in the Highlands of Scotland from Loch Lomond to Dunkeld ; in Cornwall and Devon ; North Wales and Anglesea ; in the north-east of Yorkshire ; in Cumberland and Westmoreland ; also in Wicklow and other hilly parts of Ireland.

The best beds of roofing slate lie at a considerable depth. The blocks are got out by blasting. They are split into sheets, sometimes exceeding eight feet by four, by means of long, wide, and thin chisels, applied on the edge, parallel with the laminæ, and struck with a mallet or hammer ; cross grooves are then cut on the flat face so as to divide the slabs into the requisite lengths, which are separated by a smart blow of the chisel. Each piece is next split into thinner leaves by the application of fine chisels to the edges. Afterwards the leaf is roughly dressed on a block of wood with a chopping-knife. " By long exposure to the air, after having been quarried, the blocks may lose their property of being divisible into thin laminæ. In such a case, the blocks are said to have



SLATE-QUARRY OF ANGERS.

‘lost their waters.’ Hence, in a slate-quarry, the number of splitters ought to be proportioned to the number of block-hewers.”

In France, the most celebrated occur in the Pyrenees, the Alps, and the Ardennes. But those of Angers surpass all others in the number of workmen which they employ, in the **quality** and amount of their products. They lie to the east of the city, along the Saumur road; have been worked for centuries, and export their **slates** to all parts of the world.

Their yawning excavations descend to a **very great** depth, and in these immense and giddy voids, the **workmen**, ranged upon successive stages or platforms, **detach**, by various ingenious methods, the slate from its **beds** in the quarry.

Steam-engines are employed in raising the stone to the surface, where it undergoes a special course of **preparation**. Picked workmen saw it into large slabs, **plates**, and squares, according to the dimensions required.

Other quarries there are in France, which **yield** their peculiar and characteristic products; such as those of kaolin or porcelain-clay near Limoges. They have **originated** in that city the porcelain manufacture, which for upwards of a century has flourished exceedingly.

In the Alps and Pyrenees we meet with quarries of alabaster and marble; but it is more particularly to Italy—that is, to Volterra for alabaster, and Carrara for marble—that we should resort to examine into the **working** of these subterranean products.

Let us borrow a few details from M. Simonin, who several times visited the quarries of Volterra in 1857–8.

The most important, he says, are at La Castellina, a village within a short distance of Volterra. The stone

worked in both localities is afterwards exported over the entire world in the shape of vases, cups, candelabra, clock-cases, statuettes ; the ingenious hand of the artisan gives it, in fact, those thousand elegant and useful applications with which everybody is familiar.

It is well known that this substance is soft and ductile, and easily receives the impression of the chisel. The alabaster of Volterra is frequently translucent ; at other times it resembles marble. Among the most remarkable varieties we may mention the *giallo* or yellow, reminding one of the fine yellow marble of Sienna, which was once so popular, and the *florito* or flowered, which corresponds in appearance to the gray-veined marbles of Seravezza, near Carrara. There is also a clear white alabaster, resembling the most beautiful statuary marble.

The Volterrans display a singular ability in working alabaster ; it is even probable that this industry has been handed down from father to son, from time immemorial, among this ancient people. The Etruscans, the founders of Volterra, brilliantly opened up the road in which all their successors have followed. The latter have even surpassed them, and their modern artists give proof of an exquisite taste in their drawings and compositions. They have in this respect remained true Italians, and each of them shows, with a just pride, his *Museo* ; that is, his collection of his masterpieces.

Some families of Volterranean artists exercise on a very grand scale the alabaster industry ; and while the "head" works the quarries and sculpts the stone at home, it is no uncommon thing for his sons to make the tour of the world to sell the paternal productions. India and

both North and South America swarm with them; and stories are told of merchants of Volterra who have returned home from these distant regions worth thousands of pounds. ●

In the Pyrenean bathing establishments the credulous are entrapped to purchase, for their weight in gold, the alabaster knick-knacks of Volterra, in the belief that they are made out of Pyrenean marbles. I was confidentially informed of this fact by a vender of Bagnères-de-Luchon; and I have seen at Naples some simple tourists purchasing vases of Tuscan serpentine, in the belief that they were fashioned from Vesuvian lava.

The marble-quarries of Carrara are not less interesting than the alabaster quarries of Volterra. I visited them frequently, says Simonin, in 1863-64, and seldom has any geological exploration given me greater pleasure.

The mountains in the neighbourhood of Carrara are furrowed with deep ravines, in whose precipitous sides the quarries are excavated. The three principal cuttings bear the names of *Ravaccione*, *Canal-grande* or *Fantis-critti*, and *Colonnata*: they ramify behind Carrara like the branches of an immense fan.

The valley of *Ravaccione* is peculiarly interesting to visit; it is distant three thousand yards from Carrara, while *Fantis-critti* and *Colonnata* strike off from the immediate suburbs of the town.

To the left of the road lies the picturesque village of Torano, boldly perched upon a height, with its ancient church and tiled roofs sharply outlined against the background of the picture.

At the foot of the smiling declivity are the saw-mills and *frulloni*,* of a completely primitive construction. The different apparatus are set in motion by a pendent wheel or large *turbine*, whose motive force is supplied by the water of the torrent.

We pass in front of a transversal valley—that of Pescino—where numerous quarries are also situated. These we leave behind us, and in due time we arrive at the first working—the *Mossa*—marking the first stage in the circuit of the works of Ravaccione.

It is from thence, as well as from the neighbouring quarry of La Bettuglia, that the finest modern statuary marble of Carrara is now obtained. It sells at as much as sixteen shillings the *palma*,† or about £50 per cubic yard, *in situ*.

On the occasion of my visit to the quarry, a fine block weighing 800 palmas lay on the surface of the ground, waiting for the arrival of the usual means of transport.

The value of statuary indicates the high price which is fetched by a thoroughly homogeneous and crystalline block, pure and without admixture, and the very considerable profit attending its working.

The clear white marble does not fetch half so good a price, and yet the cost of extraction and transport is just the same as for statuary marble.

* The mechanism which polishes the marble slabs.

† The *palma* is an old Italian standard, which is now exclusively limited to the measurement of marbles. The linear *palma* of Genoa, the only one adopted, is equal to about one-fourth of a French *mètre*, or nearly 10 inches; it takes, therefore, about 65 cubic palmas to make a *mètre de volume*. The cubic *mètre* of marble is calculated to weigh, on an average, 2650 kilogrammes, or a little more than 41 kilogrammes to the *palma*. A kilogramme is equal to two and one-fifth pounds.

If we continue to ascend the valley of Ravaccione, we shall see at Polvaccio an ancient Roman quarry, which, down to a recent date, has yielded a much-esteemed statuary marble. Thence the Romans procured the marble for their Pantheon, the Column of Trajan, the Triumphal Arch of Titus, and that of Septimius Severus. The Apollo Belvedere is likewise sculptured in Polvaccio marble. The blocks of which Michael Angelo made use for his "David," and for the celebrated recumbent allegorical figures of Day and Night, that adorn the tombs of Giovanni and Lorenzo de' Medici, were also extracted from these quarries. And lastly, we may cite, as wrought out of Polvaccio marble, the "Neptune" of Bartolomeo Ammanate, and the group of "Hercules and Cacus," which ornaments the open space in front of the Palazzo Vecchio at Florence.

We do not know whether Louis XIV. patronized Polvaccio; but we *do* know that the white marbles of the tomb of the Emperor Napoleon I., one of those modern works which have consumed the largest quantity, were procured from Colonnata, where the Romans also had some quarries.

There the rock still exhibits the marks of their tools. The horizontal lines left upon its surface very clearly indicate the mode of working adopted by the ancients. They loosened the mass on five sides. The anterior face, the upper, and the two lateral faces were prepared by preceding excavations; the posterior face was opened by mechanical means; and finally, with the help of chisel, pincers, and wedges, the block was forced out, by violently disengaging the lower side.

Up to the seventeenth century this mode of working marble was in general favour. But since that date gunpowder has been extensively used in mines and quarries. The acids which attack and dissolve the limestone have also been employed to facilitate the action of the gunpowder. By pouring sulphuric acid (popularly known as oil of vitriol), or either hydrochloric or muriatic acid, into a groove formed by the miner's pickaxe, a deep cavity is created; and if this be filled with gunpowder, it becomes possible to loosen and detach enormous blocks. At Marseilles, in the construction of the new docks, and at Theil, near Montélimart, in the extraction of limestone for cement and hydraulic chalk, it is hardly an exaggeration to say that entire mountains were rent in fragments. The gunpowder, employed in charges of hundreds of pounds each in the cells opened up by the acids, broke up huge masses of solid rock at a single explosion.

At Carrara and Seravezza it is unnecessary, however, to operate on so grand a scale; but five or six mines, nevertheless, are frequently fired at one and the same time. The awful report of the explosion is repeated by every echo, and flies from valley to valley like the reverberations of thunder. The block, hurled into the air, falls back heavily, and rolls down the abrupt declivities of the quarry.

Several thousand pounds of gunpowder are wedged at once into the cavity prepared for the charge, and fired by means of a safety match. These "acid mines" are called by the workmen *mines à la Française*, because their use was introduced from France into Italy.

The highest point at which the quarries are worked in the valley of Ravaccione is 2100 feet above the sea-level.

The ox-drawn waggons or trucks reach the foot of the last quarries by a good road, and along the whole route we meet them following one another in single file, or crossing, as some ascend with empty carts, and others descend heavily loaded.

To reach the points where they take in their burdens, the workmen, in various quarries, have constructed inclined planes, paved with marble, along which the blocks are impelled. Their movement is regulated by means of cables, which glide upon greased rollers. These smoke, and sometimes ignite, under the friction of the marble, like the cradles along which a ship glides on being launched into the sea.

A spontaneous descent of the blocks can take place only in those quarries provided with inclined planes. The traject is short, and the difference of level inconsiderable.

The site of the highest workings of Ravaccione is characteristically named the *Concha*, because the valley, closed in on every side, there assumes a remarkable resemblance to a shell.

The landscape is dreary and desolate. Not a tree relieves with its fresh green foliage its bare and barren limestone rocks; a few herbs are scattered here and there; and the monotony is broken by an occasional cabin of stone, serving as a place of refuge for the quarrymen.

There is no field for the agriculturist's skill and perseverance. Up to the highest points are carried the quarries, stage upon stage. Their products are the



DESCENT OF A BLOCK OF MARBLE.

ordinary or clear white marble, and the veined, a quality bordering upon blue. Statuary marble is wholly wanting. At Carrara the last-named quality is always found low

down in the valleys ; just the reverse of the neighbouring quarries of Massa and Seravezza, where it seems to prefer the most inaccessible heights.

The *Concha*, let us add, presents a singularly animated spectacle, reminding the traveller of the scenes which greeted him all along the road as he ascended the Ravaccione. Everywhere there are quarries, and in the quarries the din and clang of labour. A whole army of stalwart workmen may be seen engaged in the various processes of extracting the blocks, sawing them, lowering them down the planes, and raising them upon the trucks intended for their reception. At noon they all assemble to enjoy in common a frugal breakfast,—in the open air during summer, under cover in the winter. No ill feeling exists between the workmen in two rival quarries ; and when, as is frequently the case, the proprietors are at feud, and harassing each other with interminable lawsuits, the workmen, fortunately disregarding the custom under such conditions in other trades, do not think themselves called upon to take any part in the quarrels. And, in truth, their dangerous handicraft counts a sufficient number of victims without swelling the melancholy list by murderous and useless affrays.

Over the workmen are placed the chiefs of the works ; a kind of taskmasters, or middle-men, who usually charge for the extraction of the marble at a rate determined in advance. Having made their arrangements with the owner, they afterwards treat with the simple quarrymen, either at so much the day, or by piece-work ; and thus



MARBLE-QUARRY OF RAVENNA.

the proprietor is saved all troublesome details and the risk of possible disputes with the operatives. The proprietor or lessee of the quarry opens a running account

with his agent. To the credit side is placed the number of *palmas* quarried ; to the debit, the advances made in money, gunpowder, tools, and the like. They treat generally on the footing of a certain sum per *palma* delivered on the sea-shore, or on the quays of Carrara ; and, consequently, the expense of transport is borne by the agent or middle-man.

The marble works at Carrara are of much greater importance than those of Massa and Seravezza. At Carrara, the number of workmen directly engaged in the quarries exceeds two thousand five hundred. About one thousand are employed in the transport, despatch, and preparation of the blocks—waggoners, quay porters, sawers, hewers, and so on.

A few years ago, the total quantity of marble annually quarried at Carrara was estimated at 1,500,000 *palmas*, or, in round numbers, 60,000 tons.

The product of Massa and Seravezza together was, and is, about two-thirds of that of Carrara, or 40,000 tons ; of which 25,000 were furnished by Seravezza, and 15,000 by Massa. But if we confine ourselves to the yield of Carrara alone, we may estimate that it distributed a sum of £160,000 over the district. Thus, says Simonin, everybody is satisfied, no one complains ; the workman is happy, the owner grows rich, and everybody lives upon the marble !

If this be true, Carrara must be the paradise of labour and capital, which, assuredly, are not on such amicable terms in any other part of the busy world !

The commune of Carrara contains a population

20,000 souls, and not a single pauper ! No wonder that it increases daily. We fear lest the mere statement of the fact in these pages should induce a wholesale emigration.

The only qualities of marble wrought at Carrara are the statuary, the common or clear white, and the bluish or veined. Neither at Carrara nor at Massa is found the common dark blue and the breccia, which Seravezza produces in so much abundance and of such excellent quality. At Massa, however, of late years, a very considerable progress has been made, and some magnificent marble-works are now in operation.

The finest saw-mill at Carrara belongs to Mr. Walton, an American ; it contains at least a dozen frames for sawing the marble. They can all be worked simultaneously, and each carries about thirty blades. The blocks are brought under the machines upon iron rails. A stream of water, conveyed above each saw by ingenious automatic mechanism, sprinkles the upper surface of the blocks, and as the iron saw moves to and fro prevents it from being overheated by the constant friction. An hydraulic wheel, or, more properly speaking, a turbine of the most approved construction, sets the saws in motion.

The whole is erected in the interior of a spacious and well-designed building, which is not devoid of architectural pretensions.

At Massa and Seravezza some extensive saw-mills are also situated, but the principal products of the latter town are the *marmetti*, or little squares used for *parqueterie* and mosaic work.

The workman prepares them roughly at the quarries, by striking with his mallet on the narrow side of the block so as to split them longitudinally.

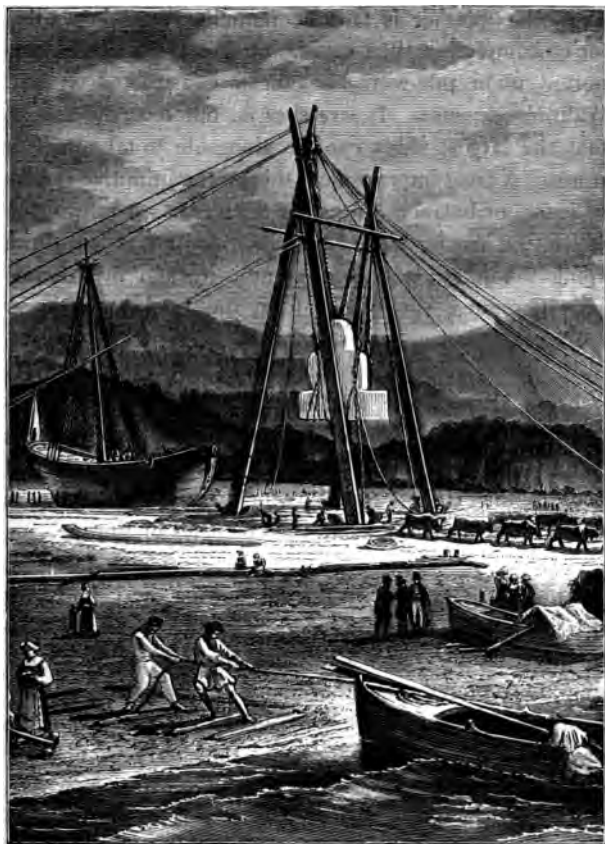
The blocks treated in this way are those characterized by natural joints or fissures, but not the less a considerable amount of manual skill and dexterity is needed on the part of the workman. His swift and practised eye, however, enables him to seize at a glance the most imperceptible fissures, and his well-trained hand promptly takes advantage of them.

The squares are afterwards split across their width with the chisel, and gradually brought to the required shape. They are then removed to the factory, where they are submitted to the action of the grindstone or *frullone*.

Let the reader figure to himself a vertical axis, or shaft, as we say in mechanics, mounted directly in the centre of an hydraulic wheel. The latter, very frequently, is but rudely constructed. The water from a neighbouring torrent falls upon the paddles, and sets the apparatus in motion.

To the shaft are attached two small beams, cross-wise, covering the entire diameter of a circular trough. In each of the compartments thus formed a certain amount of *marmetti* are placed, the side intended for polishing resting on a horizontal grindstone. When the shaft moves, it necessarily carries with it the cross-beams and the marble squares. Sand is thrown on the grindstone or mill, which remains fixed, and the friction polishes the marble.

This manufacture and polishing of *marmetti* are carried on extensively at Seravezza, but the trade at Carrara assumes very insignificant dimensions.

*THE QUAY AT CARRARA.*

The quay at Carrara where the marbles are embarked presents an appearance of much liveliness. The beach is covered with blocks of marble ; and in the roadstead,

when the weather is fair, lie numerous vessels waiting for or completing their cargo. A fine pier or jetty, supported upon pile-work, has been constructed at Mr. Walton's expense. It stretches far out into the sea, so that the largest ships can lie alongside to take in their stores. A great improvement this on the primitive system of *lancie*, or balances, in use at Seravezza. A railway, on which the trucks loaded with marble run, is laid down along the jetty; and iron cranes, worked by toothed wheels, remove the blocks from the trucks and lower them gently into the vessel's hold.

From Carrara, the marble-ships sail for Geneva, Leghorn, and Marseilles, the three principal marble depôts in the Mediterranean. Nearly one-half of the total yield goes to the United States, which consume almost as much Carrara marble as all the countries of Europe.

At Marseilles, the works for sawing and polishing marble, as well as the numerous studios for its preparation, are on a large scale. The qualities used are not only those of Italy, but those supplied by the quarries of Southern France; more particularly the greenish-white or *campan* marble of the Pyrenees, the cherry-red or *griote* of Languedoc, and the breccia of Tholonet, near Aix, known by the name of "Aleppo breccia." The beautiful onyx or veined marble of Algiers, the black marble of Liège, lumacella, and the small granite of Mons, are also wrought. The principal articles manufactured are mantelpieces, pedestals for clocks, tops for tables, and vases.

Carrara, Massa, and Seravezza are the only places which now export white and blue marbles. The Grecian quarries, once so famous, were exhausted long ago, or, at all events, they do not now attract the capital and enterprise of the West. As for the ancient quarries which the Romans, following in the steps of the Etruscans, worked in Italy simultaneously with those of Carrara—as, for example, at Campiglia, and in the Isle of Elba—every attempt to reopen them has failed. More than once new works have been undertaken at Campiglia, where all the varieties of Carrara and Seravezza are to be found. Its statuary marble is equal to theirs; nay, in some of the veins is finer, recalling by its lamellar texture and the transparency of its edges, the marble of Paros, which gives so much suppleness to the sculptor's flesh. But the works have never proved successful, though the difficulties of transport are fewer at Campiglia than at Carrara.

Cosmo I., and afterwards a Leghorn company,—it is but a few years ago,—made the attempt, and failed. Recently, a new association has been formed, which, it is to be hoped rather than expected, may be more fortunate than its predecessors. Mr. Simonin, however, is of opinion, that “an industry like that of marbles, planted at Carrara for a period of twenty centuries, cannot be displaced in this way at a single stroke.” And it appears that a good supply of water, so necessary for carrying on the present system of marble-working, cannot be obtained at Campiglia.

In Africa, at Filfila, magnificent beds of marble, formerly excavated to a very considerable extent by the Romans,

have likewise tempted, but with no better success, the efforts of a joint-stock company. In spite of the enormous tax of nearly £2 per ton at one time levied upon marble imported into France, a tax from which the marbles of Fil-fila were specially exempted, the African company could not hold its ground against the competition of Carrara. The Italian Government, we may add, spares no exertion to encourage the working and exportation of marble. All the more or less onerous customs-duties imposed by the grand-ducal government have been abolished. The labour of the quarries is absolutely free from all troublesome surveillance on the part of the State, and from every kind of administrative interference. The export-duties, and the tolls for maintaining the highways in repair, have been reduced to a minimum, namely, one shilling and sevenpence per ton, or about four shillings the cubic mètre. In concluding a commercial treaty with France, Italy demanded the suppression of the enormous import-duties then levied on the statuary marbles of Carrara. Now, therefore, they are free from all vexatious imposts, and at Marseilles the finest quality pays only eight shillings per ton. Freight from Carrara to Marseilles, however, is very high,—from twelve to sixteen shillings per ton, according to circumstances.

The railway along the Tyrrhenian coast has a station at Spezzia. As soon as a branch line shall be completed from Carrara to Avenza, the cost of transport will be diminished one-half, and the quarry-owners will escape the exactions of the insolent and idle shore-porters.

In this manner, the marbles of Massa and Seravezza

will be transported to the main line on branch lines or tramroads, and conveyed to Spezzia by rail. There, in that magnificent gulf which Nature has obviously intended for the site of the finest harbour in Italy, the marbles will be embarked at a low rate, often, perhaps, as ballast, for all the ports of the Mediterranean and the Atlantic.

After dwelling so long upon the marbles of Carrara, we must say a word or two in reference to the marble-workers, or those artists, if you prefer the term, who employ and turn to advantage these precious materials.

One of the liveliest pleasures the traveller experiences, on arriving in a town which he has never seen before, is to go alone on a tour of discovery. At Carrara this pleasure is greatly augmented by the interest which attaches to the industrial pursuits of the inhabitants, all of whom are marble-workers or sculptors. The ateliers, or studios, arrest you at every step, each bearing, upon a marble slab above the large doorway opening from the street, the name of the "professor." Beside the ateliers are the more modest workshops of the humble and unpretending *marblers*, who model, in the bluish-white marble their country produces so abundantly, baths, mortars, vases, and balustrades and statues for gardens. The metallic vibrations of the chisel resounding on the sonorous stone continually strike the ear; and sometimes, too, one catches the monotonous grinding of the saw as it wears its way through a block which impedes one's progress at the bend in the street. The iron blade, mounted in a vertical frame which is held together by

lateral cords, moves to and fro, manœuvred by the careless operative. Though paid by piece-work, that is, so much per palma, in advance, he does not hurry himself



MARBLE-SAWYER AT CARRARA.

He knows, moreover, that the saw descends slowly—a few inches a day at the utmost. But, above all things, he loves his ease. If the rain or the sun inconvenience him,

He arranges above his head either a tent or the traditional *ombrello*, which thenceforth becomes a part of the mechanism fixed around the block.

In the environs of the town the spectacle is no less curious for the stranger. Every moment he meets with the carts drawn by several pair of oxen, often by five and six at once, which are used for the transport of the marble *cubes*. There can be no doubt that these heavy vehicles are constructed on the same model as the Etruscan chariots of the ancient Luna, whose inhabitants first worked the quarries of these localities. The wheels are low, massive, heavy, with six spokes. They resemble those which Carrara carries on its escutcheon, around which you may read the old Latin name of the city, *Civitas Carraria*, or "City of the Quarries." The yoked couples, with tranquil pace and slow, drag the huge glittering block along the dusty road.

The herds run backwards and forwards, violently goading the unlucky cattle, which are unable to help themselves. However, the heavy mass continues painfully and with difficulty to advance, jolted fearfully in the deep irregular ruts.

The circular route traversed by the wains connects the town with the quarries, and bears the characteristic designation of *Via Carrareccia*.

Some of the *études* of Carrara deserve a careful examination, and among the "professors," Lazzerini, Franchi, Pelliccia, and Bonanni have acquired the greatest celebrity. All four, we may add, are professors, not only in name but in fact, since, besides giving lessons in their studios, they lecture in the Carrara "School of Arts," attached to the Academy of Sculpture at Carrara.

This academy, of which Carrara is justly proud, has produced some distinguished masters, and Canova, the Venetian, and Thorwaldsen, the famous Dane, did not refuse to be included among its honorary Associates.

Since the era of the Renaissance, the majority of sculptors have resorted to Carrara to choose their marbles. The inhabitants are fond of pointing out the house which belonged to the family of Michael Angelo. The town itself has given birth to some illustrious artists : Pietro Tacca, the pupil, and afterwards the rival, of Buonarrotti, as he is designated in an inscription on the front of the house where he was born ; Carlo Finelli, whom another and more boastful inscription, scarcely excusable even on the part of a man's fellow-citizens, calls "a sculptor second to no other ;" Franzoni, who, in the pontificate of Pio VI., worked at the Vatican ; and, finally, Tenerani, many of whose productions are well known in England.

The living masters now resident at Carrara, if they have not acquired the renown of their predecessors, not the less wield the chisel with firm and skilful hands. Signor Bonanni displays a rare ability in ornamental sculpture, and no one better than he can create in marble a posy or a garland of flowers. Signor Pelliccia, Lazzarini, Franchi, and other Carrarese sculptors, are not less successful in statuary, and their chisels have given to the world many works of the highest merit.

Below these masters come the numerous procession of *manufacturers*.

These turn out reduced copies of famous statues, a

cient or modern, and sell them to tourists at prices which are generally very moderate.

Among these copies may be found the Venus of Milo, the Venus de' Medici, the Capitoline Venus, the Diana of Gabii, or the Diana and Hind, Dying Gladiators, Mercuries, Bacchuses, Antinoüses, and Herculesees, besides all the compositions of Canova and Pradier. These are sold on the spot, or exported at so much the cubic mètre, or according to weight.

Then again, a reduction is made of a fourth or a half as the case may be; so much for a single statue, so much for a group. All ancient Olympus is for sale, and there is little difference, we may note, between the copies of two or more competitors for your custom.

America, and, in Europe, England, Russia, and Spain, purchase these productions largely, and the wrought marbles of Carrara maintain a steady rivalry with the alabasters of Volterra.

It is true, however, that complaints of diminished demand have been heard since the railway, passing at some distance from the town, has diverted the stream of tourists. Formerly, the trade was brisker. On issuing from the *table d'hôte* where the diligence stopped, you naturally paid a visit to the nearest studio, saw the professor's works in full array, and purchased a statue, just as you would buy specimens of lava at Naples, or a box of plums at Tours, or a piece of china at Dresden.

In addition to its statues, its copies from the antique, and its busts, Carrara produces much ornamental work; panels, frames for mirrors, costly mantelpieces. Nor

does it disdain the mortuary branch ; and more than one splendid tomb, commanded by some wealthy merchant-prince or grandee in Chili, Peru, Russia, or Spain, is designed and then sculptured in the ateliers of Carrara.

At Carrara, as we have hinted, everybody is more or less a sculptor. It would seem that a secret and mysterious relation exists between the physical and moral qualities of a people and the lithological characteristics of the districts they inhabit. Burat has very clearly brought out this fact in his able work on "*Géologie Appliquée* ;" and, in illustration, refers to Carrara and its marbles, and Volterra and its alabaster ; justly observing that the existence of certain rocks adapted for art-work may render those qualities common which elsewhere are rare. The geographer Repetti, studying with some care the physical aspect of this question, had already remarked that his Carrarese competitors displayed in their character an indescribable suppleness and malleability corresponding to that of their indigenous marbles.

The inhabitant of a limestone country neither thinks nor acts like the inhabitant of a region of schist or granite. In France, remarks Elie de Beaumont, one of the founders of modern geology, the expressions "*Provençal*," "*Gascon*," "*Auvergnat*," "*Parisian*," correspond to as many different geological districts.

In the Academy of Carrara the visitor will find careful copies of every antique or modern model of any celebrity. Thither the youth of the country resort to acquire a knowledge of the delicate art of imitating *relievos* by

design and moulding. There is also a school for the study of living models. Those who are not attracted by statuary may devote themselves to ornamental sculpture, and seek in the graceful leaf of the acanthus, in the winged griffon, or the rich arabesque, the secret of their capricious outlines. The pupils crowned every year for superior merit are sent to Rome, their expenses being partly defrayed by the Carrarese municipality, and sometimes by the Italian Government.

The tourist should notice, in the Academy of Carrara, an ancient bas-relief, of much interest in an archæological and historical point of view.

This bas-relief, which the academy acquired a few years ago, was sculptured, during the Roman epoch, on a block of pure Carrara marble.

The quarry whence the block was taken gained, in the Middle Ages, and has preserved to the present day, the name of *Fantiscritti* (literally, "soldiers sculptured"), in allusion to the subject of the bas-relief, or, rather, to the explanation popularly given of it.

The interpretation put forward by the Italian artists and archæologists is this: Jupiter, Hercules, and Bacchus are assembled together, face to face. The Father of Gods and Men, easily recognized by his long flowing beard and "ambrosial curls," occupies the centre; he rests his arms paternally on the shoulders of his companions. To the left is Bacchus, whom we are assisted in distinguishing by the thyrsus which he holds in his hand ;*

* Other authorities suppose this figure to represent Mercury; in which case the thyrsus becomes a caduceus; a supposition quite allowable, owing to the worn condition of the bas-relief.

on the right, Hercules, clad in the skin of the Nemæan lion, carries his formidable club.

All the quarriers, and all the artists who pass through Carrara, visit the academy to examine this bas-relief. Many sculptors have engraved their names upon the stone, Pietro Tacca, Gianni Bologna, and Canova being among them. From the elegance and depth of the incisions, you can easily see that these names were engraved by hands accustomed to the chisel. It appears that the immortal name of Buonarotti once figured on the marble, but it has disappeared; either carried away by some unscrupulous fanatic, or broken off with a fragment which has been detached from one of the corners.

In another Roman quarry, at Colonnata,* near Carrara, the attention of visitors used to be drawn to the remains of a votive altar, which we learn from its inscription was erected by Villicus, decurion of the slaves engaged in the excavations. A few years ago this altar also was removed to the academy at Carrara. It fully justifies the favour in which the indigenous marble was held by the Romans. Prior to their epoch, indeed, the Etruscans had worked the Carrara mountains; and the town of Luna, which they reared on the neighbouring shore, depended on the marble industry for its prosperity. But it was not until the time of Julius and Augustus, when the quarries of Greece began to fail, when the Pentelicus and Paros refused to the Masters of the World the treasures they had so freely yielded to Phidias, Ictinus, and their pupils,

* From *Colonia*, a colony, because founded by a colony of slaves.

that the Romans turned to the resources of Carrara.* The white crystalline marbles of Luna regained their ancient renown, and for several centuries, down to the fall of the Empire, furnished all the artists of Rome, architects or sculptors, with the material indispensable to their æsthetic pursuits.

At the epoch of the Barbarian Irruption the quarries ceased to be worked, or were worked with little energy. Luna, which had shown symptoms of revival, and had embraced the Christian faith, was a second time ruined by the fire and sword of the Northern conquerors.

Woe to the towns traversed and connected by the *Via Aurelia*, on the littoral of the Italian peninsula !

For it was by this route that the fire and sword of the Goths, the Lombards, and, at a later date, the Normans and the Imperialists, poured in upon the suffering land. It was by this route, too, that the Saracens came to plunder and destroy. Luna, once more devastated, this time sank to rise no more ; and men were on the point of losing even the recollection of the glorious marbles of Carrara, when noble Pisa, with her heroic sons, began the Renaissance of the arts in Italy. In the eleventh century marble was wanted by the architects intrusted with the task of building the Duomo, the Baptistery, the Leaning Tower, the Campo Santo ; and it was towards Carrara that they turned their steps. Thenceforth the quarries have resounded constantly with the clang of mallet and pickaxe.

The beautiful churches of Lucca, models of Lombard

* Pliny, " *Historia Naturalis*," lib. xxxvi.

architecture, and the palaces of Genoa and Pisa, are built of Carrara marble, whitely gleaming beneath the deep azure of an Italian sky. When the arts in any European country have reached their apogee, their point of supreme prosperity, their fullest development, then the working of the quarries has attained its most brilliant period, just as it is infinitely less active in their hours of sad decay.

Thus, the age of Leo X. in Italy, and the age of Louis XIV. in France, were most favourable to the prosperity of Carrara; as, in an earlier period of the world's history, the Etruscan era and the age of Augustus had been the most celebrated epochs of the working of, and traffic in, its marbles. As might be expected, the prosperity of the quarries has kept pace with that of architecture and the sculptor's art. Louis XIV., when embellishing Versailles, spared no expense to obtain from the Carrarese quarries their finest blocks. Their pure and spotless marble has not been reserved for statues exclusively, but lavished on the basins of fountains, on the balustrades of garden-terraces, and has even been used for inlaid pavements.* Hence the consumption has been enormous; and if some of the quarries of Carrara no longer produce any statuary marble, the reason is that the deposits have been exhausted by the repeated demands made upon them, after having been worked almost continuously for upwards of two thousand years.

* At this period the marbles of Carrara were imported into France by a very circuitous route. The blocks were transported by the Rhone as far as Arles. At Lyons they took the Saone, then the canals, and they finally reached Paris and Versailles by the Seine. Two years were sometimes occupied in the voyage. Now-a-days, by the Atlantic and Rouen, it takes two months. When a continuous iron road connects France and Italy, the same transport will require only a very few days.

As yet, however, the traces left by human handiwork are scarcely visible on the imposing limestone masses of which the mountains of Carrara are composed ; so true is it that the forces of man avail but little when brought into antagonism with those of Nature !*

The quarries of Volterra and Carrara, which we have just traversed, furnish artistic and ornamental products of remarkable beauty and value. We may now direct the reader's attention to those of a more modest character which human skill and industry have extracted from substances apparently coarse and trivial, but which are not less important, owing to the number of hands they employ, as well as to the greatness of the city that, it is no mere figure of speech to say, has issued from their abysses. We will visit the quarries of Paris.†

We must go far back into the night of ages, far back beyond the Noachian Deluge, if we would know how the rocks were formed which Paris, for centuries, has drawn from its quarries, and has used in her enlargement and embellishment. This excursion into the domain of geology, however, is appropriate to our subject ; and we hope that no one will ask us at the beginning, as Dandin in the play asks the Intimé, to pass on at least to the Deluge, since it is at the Deluge that our exordium must terminate.

* The reader who would wish for fuller information in reference to the quarries of Carrara, and especially those of Massa and Seravezza, to which the allusions in the text are necessarily very limited, will do well to consult M. Simonin's elaborate work, "*Les Pierres, Esquisses Minéralogiques*," published by Hachette, Paris, 1869. An English translation has appeared.

† The following sketch of the quarries of Paris is founded on Simonin's "*Les Merveilles du Monde Souterraine*."

The basin in whose centre rises the city of Paris forms, as it were, an immense gulf emptied of its waters, and opening in the direction of the Channel.

Crossing it in the direction of south-east to north-west, a deep furrow represents the bed of the Seine. On the unbroken margin, towards Meudon, a shore is outlined, and we recognize it here and there by the broad indentations which it cuts out upon the soil ; it is of chalk, and forms the bed of the gulf, and upon it rest all the various strata supporting the city of Paris. These strata lie upon one another in regular gradation ; so that if we imagine the Parisian basin reduced to the size of a shell, they would represent the superimposed lamellæ, or layers. The series of banks or tiers is remarkable for its admirable order. Some, it is true, fail at certain points, but not one is in any way reversed or convulsed ; we may count them as easily as we would the leaves of a book, to which, indeed, they have been compared.

The gulf is now filled, is covered with superimposed terraces ; but let us remove, in imagination, the upper deposits ; let us restore the condition of things which prevailed, in a calm deep sea, during the period of the Cretaceous formation. Then the wide expanse of waters stretched from the centre of France to the centre of England. This was towards the close of the Secondary Period.

Myriads of microscopic organisms, the Infusoria, lived in the Secondary sea.

The chalk, a soft granular rock, of the same composition as statuary marble, namely, that of carbonate of lime or pure limestone, was formed by the remains of these in-

finitely small animals. In its midst occur considerable beds of silex, produced either by the passage of waters charged with silica, or from the débris of other infusoria, whose shell was not calcareous but silicious.

Echini, cuttle-fish, different species of shell-fish, and a few fishes, have left their relics in the chalk. We meet also with the bones of struthious birds, like those of the living ostrich : so that the feathered inhabitants of the tropical deserts of to-day then frequented the future site of the city of Paris. It cannot be doubted that these birds found their way to the beach of the Cretaceous ocean, and that some, from over-curiosity or want of activity, were overtaken by the rising tide, and so came to leave their petrified remains in its chalky bed.

As soon as the Cretaceous strata were deposited the sea suddenly retired, or the bed was upheaved by one of those violent revolutions which even now are not uncommon, though, perhaps, on a less extensive scale.

Then began what is known to geologists as the Tertiary period.

Muddy waters spread over the newly-risen soil, and these waters were no longer salt, but as fresh as those of a river or inland lake. The clay they contained was deposited in thick beds upon the chalk. Trees of the palm or cedar family began to shoot up and flourish around the marshes. Remains of half-carbonized trunks, of thin strata of a dry, friable, brown-coloured coal ; scattered lumps of fossil resin transformed into amber, are the eloquent memorials of this antediluvian vegetation. Once more the soil subsided, and anew the sea rushed into

the Parisian gulf, now reduced to one-half its former area. In waters strongly mineralized, and loaded with impure carbonate of lime, a complete series of yellow-coloured banks were deposited; loose in texture, rough to the touch, and containing the imprints of numerous molluscs and crustaceans which lived in the Tertiary seas. At the base we meet more particularly with the chambered shells, round and flat, called *nummulites*, from their resemblance to metallic coins (Lat. *nummus*) in shape.

But the nummulites speedily disappear, and in the upper portions of the deposit the conical *Cerithiadæ*, with their decreasing spiral shells—pyramidal *limacea*, as Palissy called them—are most abundant. Sharks also frequent the teeming waters, and have left their teeth in the limestone beds which were then formed. Along a number of points we can follow the traces of the ancient Tertiary shores. We recognize them readily by the innumerable cylindrical cells, about as thick as one's finger, which the lithophagous molluscs excavated in the solid rock to provide themselves with dwelling-places. Even at the present day these molluscs cannot live at a great depth under the surface, or at any considerable distance from the shore.

When the conchiferous limestone was deposited, the sea a second time retired, or its bed gradually rose. In either event the phenomenon took place so slowly that the waters, in receding, abandoned beds of sand in which we now discover the thinnest and most delicate shells, admirably preserved. White and pearly, some scarcely

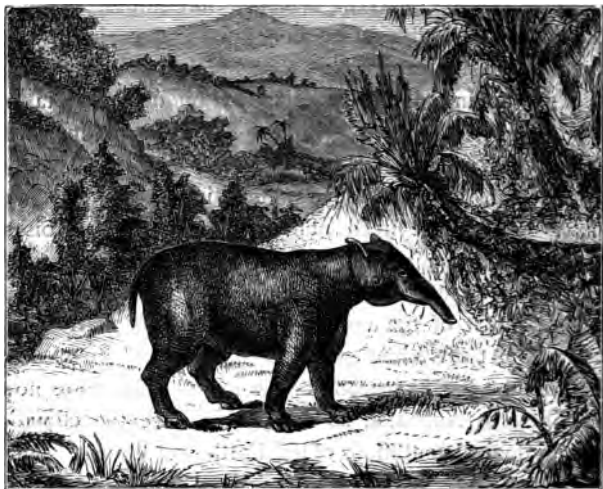
visible, they lie intact upon the sand as if the tide had just ebbed, and were on the point of returning to recover them. At some points, by a process of agglutination, these sands have been welded into compact sandstones, in whose mass we find the same shells in equally good condition.

Next came the turn of the fresh waters.

Beds of marl and argillaceous limestones, petrified lacustrine and fluviatile shells, were deposited upon the marine limestones and conchiferous sands. This series was in its turn surmounted by dense strata of gypsum, or plaster (sulphate of lime), alternating with fresh beds of marl and argillaceous limestone. On the borders of the sulphurous waters in which these deposits took place lived numerous birds, and tortoises, and crocodiles; and in the waters themselves various species of crustaceæ and fishes, all leaving their remains in the midst of the gypseous formations or marly limestones. At this same epoch, also, the sea-shore was inhabited by the kangaroos and wombats which are now confined to Australia, so completely have the climatic and biological conditions of the Earth been changed since the remote ages of which we are now speaking. There existed, moreover, in the Paris basin palæotheriums and anoplotheriums, species now completely extinct, occupying a position between the tapir and hippopotamus, and which Cuvier alone succeeded in reconstructing after the fruitless attempts of many naturalists.*

* Upon a few incomplete and mutilated bones, exhumed from the plaster-beds of Montmartre, the founder of Comparative Anatomy, guided by a most remarkable and unusual faculty of deduction, created a new science, Palæontology, or the science of fossil animals, one of the grandest discoveries ever accomplished by the human mind.

Above the gypseous formation the waves again appeared. Green, yellow, and brown marls; calcareous, whitish, and laminated marls, were alternately deposited, and among them beds of oysters; then came the turn of the sandstones and marine sands, yellow, conchiferous, ferruginous. Then, upon these, in the midst of patches

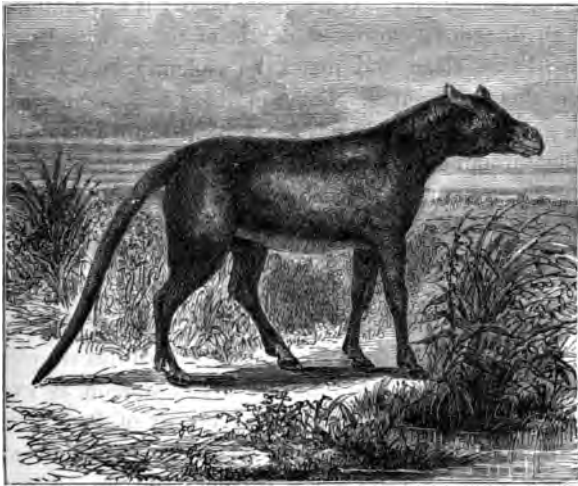


PALÆOTHERIUM.

of fresh water, forming little basins on the surface of the soil, were finally precipitated the marly and silicious rocks. These are the hard grindstone and millstone formations, honeycombed with cavities, and often petrified with shells. They represent the third of the fresh-water deposits; for there were three of each, fresh-water and marine deposits alternating with each other.

Meantime the Tertiary period pursued, over some

parts of the country which one day was to be France, the series of its formations. New rocks, akin to the preceding, were created ; coal, salt, sulphur, and iron ore. But then the basin of Paris, completely filled up and levelled, rose definitively above the surface of the waters, and the Tertiary age ran out to its last sand upon the



ANOPLOTHERIUM

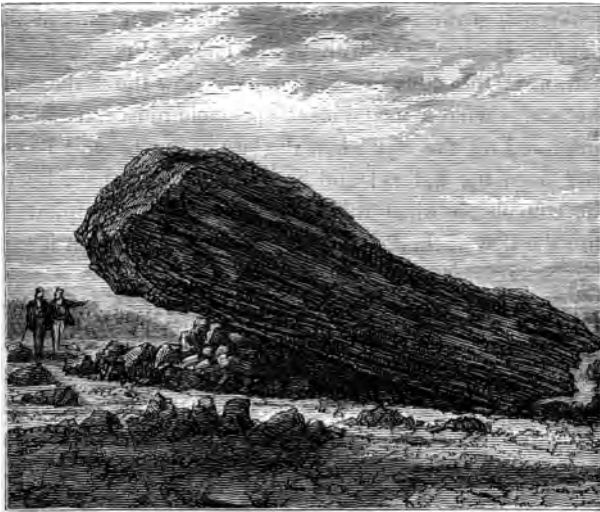
globe, though its consummation was not marked by any cataclysm.

The same cannot be said of the opening of the Quaternary period, which our geologists have so aptly named the diluvial drift ; for it witnessed the occurrence of the greatest deluges and most formidable revolutions which have ever devastated the Earth. A mighty irruption of

waters, coming from the south-east, excavated a deep channel across the Parisian basin. It has left the traces of its passage everywhere ; first, by digging out the bed of the Seine ; next, by giving to the hills and high grounds which rise above the plain—Mont Valérien, the Buttes Montmartre, and the Buttes Chaumont—their principal directions. It has done more ; it has scattered in all directions enormous débris of rocks, with ridges remarkably clean and intact, so violently and rapidly were they transported. Some of these rocks come from the granitic and porphyritic crests of Morvan, whence the deluge would appear to have taken its departure. Others have been torn from localities nearer at hand, such as the millstone grits of Meudon or Fontainebleau. Of these last, some gigantic examples were discovered during the excavations made in the Champ de Mars for the purpose of the Universal Exhibition of 1867. Profiting by so fortunate a coincidence, the authorities decided that the blocks should figure at the Exhibition as irrefutable witnesses of the primitive history of Paris ; but when the preparations for their removal were completed, it was found that they had disappeared. In all probability some masons, on the watch, had broken them to pieces to make ashlar !

The supporters of the theory that ancient glaciers invaded Europe at a certain period of the Quaternary age, affirm that the rocks found in the Paris basin were erratic boulders drifted by the ice, similar to those of which we find so many examples at the foot of the Alps, and particularly in the valley of the Upper Rhone.

At the epoch of the diluvial drift, when a portion of Europe was imprisoned in frost and snow, the Seine was probably frozen throughout its course, so that when a milder climate ensued, it would necessarily cause a vast and almost irresistible inundation, such as is now-a-days



BLOCK OF THE MILLSTONE GRIT OF FONTAINEBLEAU FOUND IN THE
CHAMP DE MARS.

common to the St. Lawrence and other great rivers of North America.

More timid theorists suggest that the erratic blocks of the Parisian alluvium may have been deposited *in situ* when the bed of the Seine was excavated by the Quaternary deluges, and amidst the demolition of the millstone grit

table-lands which then impended over the entire basin. They refuse to admit that the glaciers reached a point so far to the south ; and because the angles of the largest boulders are clean and sharp, and never blunted, they are likewise opposed to the hypothesis that these rocks were transported by the torrents. It is true that the same geologists, growing adventurous in their turn, plunge all Central Europe, and with it the Isle of France, for a portion of the diluvial era, 650 feet below the surface of the sea. What a magnificent spectacle must have been presented on the day when the site of our present Paris rose from the waters ! and how terrible must have been the convulsion when the mighty flood was precipitated into the bed of the Seine, all too narrow to contain it !

How much or how little truth there may be in any of these hypotheses we cannot determine ; but it is certain that a great diluvial cataclysm marked in the Parisian basin the dawn of the Quaternary period. The causes of this phenomenon are less known to us than those of the other changes which we have described, notwithstanding that it was nearest to us in point of time.

But it is clear that the waters cut deep into the earth. The enormous deposits of rolled pebbles and fine sand which occur around Paris—at Ivry, at the Champ de Mars, at the Bois de Boulogne, at Pecq, and in the forest of St. Germain, not to mention other places—are a convincing proof of this great geological revolution. And it was not the Seine alone which accomplished it. That river is incapable, even when its waters are highest in times of flood, of carrying down a stone as big as a

man's head, while the rocks brought by the diluvial torrents into the basin of Paris frequently weighed many tons, and the blocks of millstone grit, of which we have just spoken, measure several cubic yards. The smallest of these boulders are chiefly of silex, torn away from the chalk, polished, rolled, and now incrustated with a white coating, just as bronzes, long buried in the ground, become covered with verdigris.

Was man the witness and the victim of this terrific catastrophe? It is probable; for among the deposits have been discovered some of those flint weapons, so characteristic in their shape, fashioned by pre-historic man. The mammoths or hairy elephants, the bisons, the beavers, the large-horned elks, which peopled the old-world forests, likewise disappeared with the diluvial era. Seized upon and destroyed by the irresistible force of the great natural revolution, they have left their petrified bones deep in the beds of sand and shingle. Gigantic antlers and the molars of elephants lie there, along with the tools and implements of the human contemporaries of these extinct animals. And the modern ploughman, in turning up these strange relics, is not less astonished than the peasant described by Virgil in his *Eclogues*, when his ploughshare struck against the broken swords, and rusty helms, and human bones, which told of some long-past sanguinary battle.

Such are the events which, long before the historic ages, before even the creation of man, except in so far as regards the diluvian era, characterized the formation of

the Paris basin and the valley of the Seine. This basin has always enjoyed a great celebrity among geologists. The Brongniarts and the Cuviers have been engaged in exploring it from the beginning of the century ; and even at the present day it is upon these formations that the majority of the English, French, and German geologists ventilate their theories. The students of the French scientific schools, and those who follow the geological courses at the Sorbonne, the Museum, and the College of France, are, every summer, carefully conducted by their professors to the principal points of the basin of Paris. A very original personage, a guide, or cicerone, whose equal France has never produced—Bertrand, who knows every stratum of the Parisian formations, however thin it may be, and every shell, however great its rarity—for years has accompanied these Sunday excursions. It is he who carries in his semi-legendary knapsack the hammers, the specimens, the fossils. He, too, is the “guide, philosopher, and friend” of foreign visitors ; or, rather, *was*, before the disastrous war with Prussia interfered with scientific pursuits.

Recalling to mind the series of geological stages which we have seen deposited, we recognize that each possesses certain materials available for building purposes, and for the most varied industrial applications. They furnish us with incalculable subterranean riches, and we are able to draw up of these rocks a detailed inventory or catalogue.

At the base lies chalk, forming the foundation on which the entire geological structure reposes.

Chalk, a combination of lime and of carbonic acid gas,

is particularly valuable in the production of lime by exposure to the heat of open furnaces or kilns. Brought in contact with an energetic acid, such as nitric or sulphuric acid (*aqua fortis*, oil of vitriol), it throws off carbonic acid, the element of all the gaseous waters; mixed with clay and marl, and baked with them in furnaces, it makes excellent cements. It furnishes white chalk, which is well known to mathematicians; it enters into the preparation of paper-hangings and gilded frames; while, on account of its purity of colour and cheapness, it is extensively used to adulterate white lead, white zinc, plaster, sugar, and the like. But a much heavier substance, sulphate of baryta, collected almost solely for this object, has of late been substituted for chalk in this inglorious employment.

As for the beds of *silex* which chalk contains, they were formerly much sought after to provide flints for muskets and arquebuses. In the present day they are principally used in the repair of roadways and the manufacture of glass-paper.

The chalk is very extensively worked around Meudon. Immense galleries, opened in the soil like gigantic crypts, furnish an easy access to the excavations, where the workmen, armed with pickaxes, dig down the rock in regular stages. The white stone is broken up by wheels, set in motion by horses; then washed and cleansed in the subterranean basins. On being brought to the surface it is dried, and once more pulverized or moulded into balls.

Let us now ascend to the formation superimposed upon

the chalk : it consists of *clay*, distributed in enormous beds.

Of a bluish-gray colour, but red at some points, and especially in its upper portion, the Paris clay is remarkable for its great plasticity. It is worked by means of shafts and galleries carried beneath the surface ; or left open to the day, if the stratum lies at an inconsiderable depth. The immense workings at Issy are conducted on the latter method.

The clay is wrought in regular, soft, malleable, and remarkably homogeneous blocks. By means of some very simple manipulations, followed by a process of baking, it is made into bricks, tiles, drainage tubes, pipes, chimneys, vases, and earthenware of all descriptions. The Paris pottery, which once enjoyed a considerable renown, was manufactured of a white and very pure variety of this clay, which at Sèvres is still employed for divers purposes. Some sculptors employ the plastic clay of Paris for making models.

The *Shell Limestone* which lies above the clay is the best kind of freestone and ashlar. French geologists designate it by the name of *calcaire grossier*, in allusion to its coarseness of grain. Some hard and silicious varieties, found at Bagneux, are employed in preference for constructing flights of steps, as in those which lead up to the church of La Madeleine at Paris ; other varieties, of looser texture, are used in making filters. But it is mainly due to its qualities as an ashlar and freestone of the first quality that the Parisian *calcaire grossier* owes its reputation.

Light, porous, and granular, it readily absorbs or takes up mortar; soft, but hardening by exposure to the air, it is not much affected by the action of frost; it is easily worked, and preserves the shape and mouldings given to it by the chisel for an indefinite period. The magnificent pile of Notre Dame sprang entirely from the ancient quarries of Ivry. Nearly all the materials used in the erection of the monuments of Paris have been procured from the local strata of limestone. London and Paris rest on two great basins of the same clay; but that of London rose from the depths of the primeval sea at an earlier epoch than that of Paris, and was not again submerged, while the Paris basin, as we have seen, was sunk and elevated several times, gaining each time additional strata. Hence Paris is a city of stone, and London a city of brick.

In the course of the historic centuries, from Julian to Napoleon III., Paris has risen yet again, but after another fashion—from beneath the surface—and has built itself, one may say, stone upon stone, with the elements of its own soil.

It is owing to its innumerable quarries that the late imperial government was able to demolish it in nearly every quarter, and reconstruct it as if by enchantment. However, the mine is not inexhaustible, and the authorities have found themselves compelled to call on the quarries of some of the departments to furnish a supplemental supply. The railway system enables them to send their materials to Paris with comparative ease and economy.

All around the capital enormous excavations are to be

seen, which bear witness to the labour of many generations ; some of them, perhaps, dating back a score of centuries.

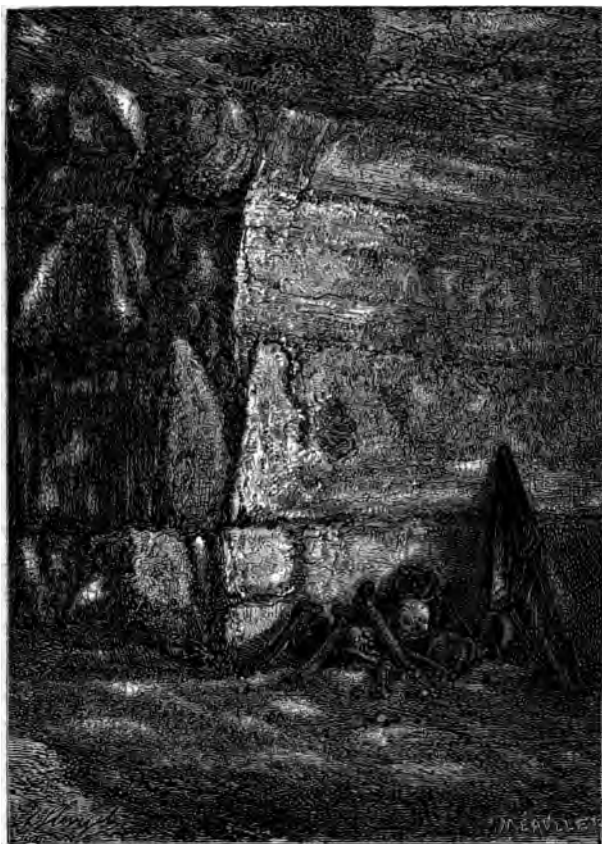
Many lie underneath Paris itself, under the ancient *Lutetia*, all around the hill of the Pantheon, in the Quartier St. Jacques. They form the Catacombs in which repose the bones of thirty generations of Parisians, removed from the cemeteries of the churches, and the ancient charnel-house of Les Innocents.*

The old abandoned quarries which form no part of the Catacombs are utilized, in the neighbourhood of the fortifications, for less noble purposes. Mushrooms are there cultivated in abundance, on beds of manure accu-

* The idea of converting to this purpose the ancient quarries of the capital is due to M. Lenoir, Lieutenant-General of Police under Louis XVI. It was he who rendered the measure necessary by demanding the suppression of the church of the Innocents, the shutting up of its ancient graveyard, and its conversion into a public highway.

In 1786 all the arrangements were made which seemed needful for suitably appropriating the place intended to receive the bones exhumed from the cemetery of the Innocents, and, in due succession, those removed from all the other graveyards, charnel-houses, and mortuary chapels of Paris. The condition of these quarries, which had been disused for centuries, the weakness of the pillars, the landslips, the depression of the soil at many points, and the excavations, previously unknown, of the lower quarries, were all so many motives to determine the municipal authorities to employ the greatest care and diligence in the necessary works. Underneath every street whose buildings rested on the excavated soil a gallery or two were opened, according to the breadth of the roadway, so as to divide the respective districts, isolate the blocks of houses, render feasible the determination of the several properties and their extent, fix their boundaries exactly below the superficial limits, and trace, at a depth of one hundred feet, the centre of the party-walls exactly under the central line of their thickness ; in fine, to establish an intimate relation between Above and Below, and create, as it were, the subterranean duplication of a considerable portion of Paris.

It is in accordance with this system that the consolidation has recently taken place of an important section of the Boulevard Arago, between the Place d'Enfer and the Rue Mouffetard. From its starting-point as far as the Rue de la Santé the road is traced above the Catacombs. This circumstance has led to the construction of enormous piles of masonry, supporting subterranean arches which form, as it were, an immense viaduct, upon which the entire Boulevard is solidly based.



THE CATACOMBS OF PARIS.

mulated beneath the surface. Formerly, too, they served as places of refuge and concealment for smugglers, who carried on their "profession" with less courage, but cer-

tainly with more profit, than the picturesque *Bandoleros* of Spain.

Entering, with their contraband burden of spirits, the quarries outside the wall which marked the limits of the *octroi*, or municipal taxation, they emerged from them *within* Paris, by means of other quarries opening into the cellars of certain houses, belonging to themselves or their accomplices. The fraud, carried on by these subterranean artifices, was not easily detected. But at length the municipal authorities, by calling to their aid the officials of the Mines, Bridges, and Causeways (*les Mines et les Ponts et Chaussées*), succeeded in defeating it. The engineers intrusted with the superintendence of the quarries broke into every suspicious cellar, and effectually walled them up for ever.

The limestone beds which crown the strata of freestone and ashlar, and belong to the same formation, are argillaceous, disintegrated, and among the quarriers are known by the name of *caillasses*. These, with some lower beds of inferior quality, are employed in the manufacture of cement. Everything is taken advantage of, and the limestones, it is evident, obligingly lend themselves to the most various uses!

The principal quarries now in work are distributed around Paris, but lie more particularly on the left bank of the Seine. At Ivry, at Arcueil, at Montrouge, we come upon the mouths of the subterranean shafts, or the yawning abysses of vast excavations open to the sky. The shafts are surmounted by colossal *roues à chevilles*,

by means of which a cluster of men, with their feet on the bolts (*chevilles*), haul up, by a cable coiling on the axis of the wheel, the monoliths dug out beneath the surface, and propped erect on their natural beds with wedges and crow-bars. The high vertical wheels of the shafts of the quarries, armed with their long thick spokes, and their circumference bristling with bolts, lend to the landscape an original and certainly a singular appearance.

But we must continue our ascent in the geological series. The *Sands* which lie above the limestone are useful in glass-making and the manufacture of refractory bricks; that is, bricks which will withstand the action of fire. Naturally agglutinated, these sands also furnish some very hard sandstone, much used for paving, especially at Beauchamps, in the department of the Seine-et-Oise.

The lacustrine *Limestone* deposited upon these sands, and the marine sandstones, are of no value. Those beds of fissured marl and coarse limestone, conspicuous in the excavations which the improvements of Paris under the Empire rendered necessary in the neighbourhood of the Boulevard Haussmann and the triumphal Arc de l'Etoile, were an embarrassment to the labourers themselves, who had no means of disposing of the unprofitable material.

The *Gypsum* which succeeds these strata of limestone replaces them most advantageously, for it is the well-known plaster of Paris. As in the case of the clay and

freestone, the quarries are either subterranean or open. Gunpowder is used in working them. Underground, the solid mass is cut out in pillars, which are attached to the mass by one of their angles, and carefully embanked by the workmen. A plaster quarry of this kind, with its



BLASTING WITH GUNPOWDER IN GYPSUM QUARRY AT MONTMARTRE.

long galleries, its excavations, its railways on which the trucks are conveyed from point to point, reminds the visitor, on a reduced scale, of a coal-mine.

Plaster of Paris is certainly not less celebrated than the Parisian freestone and limestone, and under the

name of Montmartre gypsum it enters successfully into competition with the most famous plasters. As with the limestone, we may say that the gypsum has been worked at Paris from time immemorial,—or, at least, for nearly twenty centuries; from the day when Cæsar's warriors placed their grasp so firmly on the Parisii of Lutetia that it has never since been loosened.

In the Middle Ages, plaster of Paris was used to fill up the interstices between the timber frames of which the houses of the Parisian poor were then constructed. It was also employed, as it now is—thanks to its spotless whiteness—for all the interior mouldings and whitewashings. History does not tell us whether the Italian plasterers then resorted to the capital, as they do now, to mould in this material their graceful little images. Dante, who studied at Paris, refers to the Lombard bankers then established there, but does not allude to the Peninsular moulders.

It would seem that they did not visit Paris until later; not, indeed, until after the Renaissance, when the revival of sculpture awakened a taste among the populace for the white *figulines*. Now-a-days, these nomadic artists, settled around Montmartre, Belleville, and at La Villette, mould in this yielding plaster all kinds of art objects. Sometimes they take to the Venus of Milo and the Diana of Gabii, sometimes to the Holy Virgin and St. Joseph; and all these at the lowest price, for they do not have to pay the *réduction Collas*, and frequently avoid even the patent duty.

Who has not met these strange artists, the countrymen of Dante, at evening, upon the boulevards and

along the quays, carrying their museum on their head, or resting it upon some convenient post?

The parapets of the bridges, and the railings of certain hotels—in the Quartier Bréda, for example—are their favourite stations.



GYPSUM QUARRY AT MONTMARTRE.

Pause, ye who pass by indifferently, and bestow a glance upon their exhibition—frequently it is worth the trouble—and recognize in all these groups and figures the employment, as felicitous as it is useful, of one of the commonest and purest materials of the Paris formation,

—its gypsum or plaster of Paris, which, after it has been calcined, rivals the very snow in whiteness.*

The plaster is baked, like lime, in open furnaces, or else in enormous heaps. Under these heaps; protected by a roofing which rests on two walls, certain vaults are constructed, and duly filled with brushwood and bundles of twigs for fuel. The plaster, during the process of calcination, throws off all its moisture. When tempered, it readily mixes again with water, for which it has a natural affinity, and gradually assumes a solid condition; a property which explains its usefulness for moulding, whitewashing, and the like.

With respect to lime, a nearly identical phenomenon takes place. In calcination, the limestone loses its humidity and carbonic acid, and passes into the stage of quicklime. This, extinguished by means of water, and mixed with silicious sand, seizes upon the silex, and yields a hydrate and a silicate of solid chalk, which readily adheres to stone, and frequently combines with it. What wonderful phenomena are these chemical decompositions and recombinations! The ancients accidentally discovered them, but it was left for modern science to explain, and, thereafter, to induce or modify them, according to the object it wishes to attain.

Plaster of Paris is employed not only for building purposes and in the arts, but also as a manure for the soil. The consumption of it is truly enormous.

* The trade of the moulder in plaster of Paris has been glorified by Wordsworth, who has contrived to surround the "Italian Image Boy" with a halo of poetry.

The green and variegated marls which cover the gypseous deposit are nearly everywhere worked simultaneously with the gypsum; as at Montmartre, at the so-called American Quarries, near the Buttes Chaumont, at Pantin, and on the left bank of the Seine.

These marls, either alone or combined with limestone, are principally used, when calcined, in the manufacture of cement and hydrate of lime.

Here we meet with those industrial applications which recently engaged our attention. A new element intervenes in the manufacture of the mortar; namely, silicate of alumina, aqueous or non-aqueous, which combines with the silicate of lime. The whole results in *cement* or hydraulic mortar, which adheres immediately in damp localities, and even under water. Certain varieties are proof against sea-water itself.

Must we continue to unfold this catalogue of the subterranean wealth of Paris?

Shall we speak of the millstone-grit, and the yellow ferruginous sands, and upper sandstones?—the first employed not only as grinding-stones for mills, but also, in building, as ashlar of excellent quality, hard, cavernous, and readily incorporating with mortar; the second, rejected by the *limousins*, or rough-wall masons, as too ferruginous, but used in kitchens for polishing copper vessels, and in restaurants and inns for sanding the floors; and the third employed everywhere for pavements.

With the sandstones of Fontainebleau, the Romans—those famous builders and excellent judges of building materials—laid down all their causeways around Paris.

It is not many years ago since, in the neighbourhood of the Petit Pont, a Roman *via* was uncovered, which was paved with large slabs of sandstone, laid close together. They resembled the slabs of basalt which still pave the Appian Way in the Roman Campagna. The silicious slabs of the ancient *via* of Lutetia were carefully removed to the Museum of Cluny, where, in a corner of the garden, a portion of the immense mosaic has been relaid.

Now-a-days, it is neither sandstone nor flint, but granite, porphyry, and basalt, with which Paris is paved; and yet its municipality are not so successful in their work as were the Romans.

The incessant movement of the vehicles which circulate day and night throughout the busy capital seems to defy all the ingenuity, all the calculations, and all the devices of the Parisian *œdileship*.

In vain do Normandy, Finisterre, the Vosges, and Auvergne furnish alternately their granites, their porphyries, and their best basalts.

The hard sandstone of Fontainebleau was first vanquished; and as for the flint, if it wears out the iron shoes of the horses and the iron tires of the wheels, these, by an effect of forced reaction—in the same way that the rope of the well wears out the edge of the curbstone—pulverize it in their turn, and change it into that liquid mud or tenacious dust, which makes the “*macadamization*” of Paris, on wet days as well as on sunny and windy days, the most detestable of inventions. It is said that the system of Macadam came from China, as well as the mariner’s compass, the printing-press, and

gunpowder. The Chinese were welcome to have kept it and gunpowder to themselves.

The rolled pebbles of flint with which the causeways of the Boulevards are macadamized, we draw from the diluvial drift. We know they are worked also in the beds of chalk, whence, however, the waters at many points have washed them out, on the occasion of the last denudation of the Paris basin. It is principally on the left bank of the Seine, around the Champ de Mars and the École Militaire, at Grenelle, that these great beds of sand and rolled pebbles are worked. Immense excavations are open in that ancient bed of the Seine, and the workmen, armed with pickaxes, demolish the already disintegrated rock. With sieves they sift the stones from the fine sand. The latter is reserved for making mortar, while the stones are used in relaying the roads, or in the preparation of concrete ; a mixture of hydraulic mortar and rolled pebbles, very valuable for foundations, the spandrels of bridges, and similar purposes.

At Grenelle, through the sand-pits and gravel-pits, it is easy to reach the level of the present bed of the Seine. A sheet of water, an extension of that of the river, soon filters into the excavation. This is the limit fixed for the labour of the quarrymen. They can descend only a few feet lower, by means of hand-dredges pierced with holes, which retain the sands and stones, and allow the water to flow through.

To sum up. All that we theoretically foresaw in the first part of this unpretending monograph on the geo-

logy of the Parisian sub-soil, has been everywhere confirmed: every material which the builder requires is to be found in the neighbourhood of Paris. Brick clay and tile clay, limestone, cement, plaster, ashlar, freestone, sandstone, sand, gravel, are everywhere eagerly worked, and have given rise to some important and interesting industries.

We must now say a word of the workmen who labour in these excavations, and speak of the quarrymen, now that we have done with the quarries.

We are unable to include in the same category all the workmen who toil in the quarries of Paris. Those in the chalk-pits are not identical with those in the clay; the quarrymen, properly so-called—those who quarry the freestone—do not resemble the plasterers, nor the latter the diggers of gravel. Yet all these workmen are distinguished by at least *one* common characteristic: the majority are strangers, and come from Normandy, Picardy, Burgundy, Lorraine, Brittany. These are migratory “navvies,” and, as such, have not brought with them those habits of order, economy, stability, which make good workmen. They are turbulent and quarrelsome, waste their wages in drink, religiously keep holiday on Monday, and willingly get up a “strike.”

This army of irregulars varies not only with the nature of the quarries it works, but also with each quarry. It is a legion of Bashi-Bazouks, without chiefs, without discipline. But, we must own it, courageous, energetic, susceptible of sustained exertions, they supply a want, and render a great service to society by placing their

muscles and sinews at the disposal of one of its most indispensable industries—that which has for its object the extraction from the soil of the materials of construction.

In this army of labour the wages are high, and the best-paid workmen receive as much as five shillings per diem. The pay is still higher when they work by piece-work—at so much the cubic yard, for example. The exertion is very severe, however. In the chalk quarries the best-paid labourer is the marker, who traces the *notch* upon the bank; in the clay, the digger, who, armed with his mattock, erect or on his knees, painfully divides into clods the unctuous and resisting earth; in the limestone, the *soucheveur*, who, lying on his side, excavates underneath the bank on one of its faces, so that it may afterwards fall empty, in *porte-à-faux*; in the gypsum, it is the miner, equipped with his auger, boring the hole intended to receive the gunpowder charge. These are the picked workmen, the quarrymen *d'élite*. The porters, diggers, carters, are but of minor importance.

The systems of working are very ancient, and anything but perfect, though the Department of Mines has for a century had the Parisian quarries under its charge. The functions of the department, however, are only indirect. It sees that the police regulations are observed, that the subterranean plans are duly kept up, that the geometrical limits imposed on the workings are not overpassed, and that no one of them encroaches on its neighbour; finally, that all the measures indicated by science for the embankment and propping-up of the ex-

cavations, and the general security of the mines, are everywhere adopted. To this the duty of the department is restricted ; it is preventive, and not inquisitorial ; and it discharges its duty with much skilfulness. It interferes but little, as we see, in the technical part, and leaves the workers almost entirely free as to the methods they choose to adopt. Hence comes it that the latter have made little progress. Peg-wheels, lathes with oblique winches, and horse-traction, interior or exterior, are still employed almost everywhere. For the greater number of the quarrymen, the steam-engine and all the perfections of modern mechanism, all the progress which mineral industry has realized in the present generation, may be regarded as non-existent. And so great is the force of routine, that the workmen not only do not demand, but stoutly oppose, the introduction of every novelty, and this at the very gates of Paris. It is right to add, however, that, at certain points, the more intelligent and far-seeing proprietors of quarries have adopted all the new methods.

It is not alone in the retention of superannuated processes and antiquated apparatus, it is also in the absence of all knowledge of the geology of the formations they are excavating, that the absence of enterprise and foresight on the part of the Parisian quarrymen is conspicuous. With them, the petrified echini of the chalk are *châtaignes* (chestnuts), the belemnites or cuttle-fishes *sucres d'orge* (barley-sugar), and the fossil shells of the *calcaire grossier* "snails," as in the days of Bernard Palissy.

How often we have wished to gain an insight into the way in which these rude workers regarded the great beds of bivalves so plentifully distributed through all the limestone strata, and yet have never succeeded in gaining aught other than evasive answers !

"Do you not think," we have said to them, "that the sea must have flowed over this spot, since it has left here so many shells?"

"We do not know : it is possible," the least ignorant have answered.

Others have said : "Shells ? They resemble shells, but such they are not really. The stone has thrown them out : they are forms of snails which are in the solid rock."

The idea of the Deluge never even occurred to their mind.

We said no more, remembering that scarcely a century ago even men of science had looked upon the fossils as mere freaks of nature ; what the quarrymen and Tuscan miners, with their intellect barely awakened, always designate a *giocco*.

Some of our Parisian quarrymen, when pressed a little, pronounced the words "earthquake," "convulsions," as if they had some vague idea of the cataclysms which had governed, if not the formation of the Parisian basin, at least that of other strata ; and this was all : after giving these reasons, they held their peace.

One of them, by accident, showed himself more adventurous than the others. We met him at the sand-pits of Meudon, in the forest, and we began to chat. He was

an old soldier, had been in the African wars, and afterwards had served on board ship. On returning to Paris, he had obtained employment in the quarries.

First he had worked at Montmartre, where he pretended to have found the relics of a fossil ship. On observing our astonishment, he remarked :—

“I could not be mistaken, for it still preserved its outline ; and I know what a ship is, for I am a Breton, and have been to sea. Besides, we find many fishes and shells in these strata ; why not boats ?”

We were silent ; for we had no answer to give to such convincing reasons.

If the quarrymen of Paris are, for the most part, incredulous as to the facts of geology, they accept with implicit confidence their old legends and traditions.

Here is a story which we picked up at Ivry.

A workman brought to us a Paris coin of the time of the Valois kings, found in an old excavation. We recommended him to preserve very carefully all such treasure-trove, pointing out its utility in the illustration of local history.

“As for your old sous, your old coins, they are worth less than nothing,” replied the quarryman in his energetic language ; “but as for a liard of Pharaoh, that is something very different !”

“A liard of Pharaoh ! What may that be ?”

“What, monsieur ! Do you not know what a liard of Pharaoh is ?”

“I have not the least idea.”

“Well, it is a treasure lost in the quarries in the time

of King Pharaoh ; and whoever finds it will be a rich man for life !”

“ A good chance, my man ; be sure you find it !”

“ I wish I could.”

Thus, at the gates of Paris, we chanced upon an Oriental, or, at all events, a Freemasons’ legend.

Shall we venture, after having spoken of the usual inhabitants of the quarries, to attempt a description of those birds of passage we meet with principally in the neighbourhood of the plaster-quarries, such as Montmartre and Belleville ? The so-called American Quarries are specially famous as the resort of labourers out of work, who present a very singular contrast to those whose habits we have sketched.

The deep winding galleries of the quarries afford them a place of shelter, but they are especially partial to the summit of the plaster-ovens, which are protected by a roof, and where a gentle warmth prevails. There they sleep, on the stone which is undergoing calcination ; while it is in the subterranean passages they conceal themselves, when the police spread their nets, and attempt to surprise them. In the morning at early dawn, and in the evening at twilight, like true nocturnal birds, they quit their refuge to resume their prowling expeditions.

They go in little troops ; two by two, three by three,—one to keep watch, the other to act. They carry away from the doorstep the milk-woman’s pail while she is looking in a different direction ; from the butcher’s stall his best joints of meat ; from the grocers’ shops their tin cans of preserves ; and they make off, as they steal along

the busy streets, with here a pair of boots, and there a pair of trousers.

And all this is done with the most innocent air in the world.

Then all return to their rendezvous ; they hold counsel, they set forth their booty, and they divide it. He who comes back empty receives his share, on condition that he shall be more fortunate next day. He who has too many articles of clothing exchanges them for an additional supply of food. It is a kind of *Clearing-House*, modelled after that of London, where the city-bankers, every morning, exchange their respective drafts.

These inventive chevaliers of industry, who have so vague an idea of *meum* and *tuum*, call themselves *gouapeurs*, a term borrowed from the slang of Paris. It signifies that they are both lazy and dissolute. They are of all ages.

One day we went to visit the American Quarries. At our approach the *gouapeurs* decamped in a body. The most inoffensive stranger's physiognomy will suffice to put them to flight, they live in such dread of the surveillance of the police. Observing a heap of rags lying on one of the kilns, we asked our guide the meaning of it. "Oh, the *gouapeurs* have been here," he replied, and he related to us the facts which we have just put on record.

We plunged deep into the labyrinthine galleries while listening to this curious chapter from the true "Mysteries of Paris."

Gradually the *gouapeurs*, finding they had to do with a peaceable visitor, returned. The weather without was

cold and frosty, but in the neighbourhood of the furnaces a gentle temperature prevailed. We approached. The assemblage was complete, with the exception of an old member who had died on one of the kilns the day before. He had lain there asleep instead of going out on the usual marauding expedition. The gases evolved by the calcination of the gypsum had suffocated him, and his body had been carried to the Morgue that very morning. Such accidents are by no means of rare occurrence, but no one heeds them.

One of the gouapeurs, wrapped up in an old yellowish cloak, such as you see in Murillo's pictures, shivered with fever. Others were eagerly devouring the preserves which they had stolen, an hour or two before, from the shops of unfortunate tradesmen. Sardines, in their neat tin cases, seemed a favourite dainty. Some, folded in the filthy mantle which formed their sole clothing, lay stretched upon the ground, digesting their breakfast, or half asleep, like Arabs intoxicated with *haschisch*.

Among them were a few old men, and a large proportion of young vagabonds. We joined in the conversation; but it quickly took a turn which forced us to leave the spot. We regret that we cannot here transcribe any of the replies, witty as some of them were, which our interlocutors darted at us. In the days of Rabelais one might have written down these dialogues, full of humorous allusions; but it is the admirable rule now-a-days that *maxima reverentia debetur lectori*,—the greatest respect should be paid to the reader. We confess that we could not but feel a secret sympathy with these rogues, a kind of tender compassion for them! Yet they were absolutely

insensible and indifferent to the motives which govern honest men; and it was easy to see that an inveterate abhorrence of work had driven into evil courses the whole nest of vagabonds.

In truth, it is only a sense of personal interest, according to Simonin, which prevents them from breaking the law even in the places where they take refuge. Yet in the quarries, or furnaces, it must be owned that they are never guilty of the slightest misdemeanour. And, on their side, the quarrymen never molest *them*, being well aware that they might easily become very dangerous neighbours. They live, therefore, on terms of mutual forbearance. Only, at intervals, the police indulge in a raid into the plaster-quarry neighbourhood. But what can they do with these barefooted wretches when they have caught them? So, when the prisons are full, and the offences of which they have been guilty are not very heinous, they set them at liberty; and, next day, these voluntary Pariahs resume their dishonest courses. In winter they cower and huddle around the furnaces; in summer they go plundering in the fields and orchards, and steal the fruit as fast as it ripens.

CHAPTER IX.

THE GREAT MINES : TIN, LEAD, AND IRON.

Tin : its value as a metal—Tin-mines of Spain and Germany—In China—Tin in Great Britain—Antiquity of the tin trade—The Cornish tin-mines—Copper—The Botallack mine—The Cornish miners—Reduction of the tin ore—Gold as a metal—Gold in England—Gold extracted from lead—The lands of gold—Silver—The silver-mines—Lead—The lead-mines of Great Britain—A visit to Allenhead—Going down a lead-mine—The miners and their habits—Value of iron—The antiquity of this metal—Iron in Great Britain—Iron-mines of South Wales—An impressive scene—Description of a blast furnace—Iron-producing districts—The end.



METAL which every Englishman will regard with special interest is Tin ; not that it is particularly valuable, that it is connected with any important development of art, or that it contributes largely to the national resources ; but because it first brought our island within the boundaries of the civilized world. It was in quest of the products of our tin-mines that the Phœnicians first visited our shores, and the commerce which was thus originated seems to have attained no inconsiderable proportions. It was maintained by the Romans after they had established their supremacy over England, and the Isle of Wight appears to have formed a central depot ; receiving the tin from the mines of Cornwall, and exporting it to Marseilles and other ports on the Mediterranean.

Spain, in the Roman period, also furnished to Europe and Africa considerable quantities of this metal ; but its mines were abandoned and filled in, when, after the invasions of the Barbarians, it became the battle-field alternately disputed and occupied by the conquering hordes of the North and East. We may add that the Spanish tin-mines have never recovered their former importance. Some companies have been formed of late years for the scientific extraction and treatment of the ores concealed beneath the surface of the Peninsula ; but either from want of sufficient capital, or owing to the disturbed state of the country, they have not obtained very satisfactory results.

About the middle of the thirteenth century Germany began to turn its tin-mines to account, and soon acquired, in this branch of metallurgical industry, a superiority which induced Queen Elizabeth to import German engineers and workmen to improve the imperfect processes of our English mines.

As late as 1800, France undertook to develop the mineral wealth of its own soil. Deposits were discovered and worked in the departments of the Upper Vienne and the Lower Loire ; but, unfortunately, were soon exhausted. More recently, the French have directed their attention to some mines on the coast of Brittany ; and a company has been organized to carry out their development, under the title of the *Compagnie Minière du Morbihan*.

But in Europe the richest and best-worked mines, even at the present day, are those of Devonshire and Cornwall, though their production is on the decline. The annual amount raised exceeds sixteen thousand tons of

dressed ore, or nearly eleven thousand tons of the metal. There are tin-mines in Bohemia and Saxony, but not of great importance.

Ores of this metal are also found in several provinces of the Chinese Empire ; but the largest, and probably the richest, deposits occur in Malaysia,—that is to say, in the peninsula of Malacca, in most of the islands situated between that peninsula and Java, and even in the latter island itself, so that they extend over an area of nearly twelve hundred miles in length. The mines of Banca were accidentally discovered early in the eighteenth century, and they exceed in wealth even those of Cornwall. Like all the Malaysian mines, their ores are found in alluvial deposits ; and the metal is obtained by the simple process of washing the earth. It is of the best quality, and capable of being converted into what is known as *grain-tin*. The mines, or, more correctly speaking, the excavations whence the ore is obtained, are perpendicular shafts, not exceeding twenty-five feet in depth. After clearing away an upper stratum of common clay, the miners reach the stratum of disintegrated granite and other rocks containing the tin ore. The ore is separated from the gangue by being subjected to the action of a stream of running water. It is afterwards collected in small heaps, and purified in reverberatory furnaces.

In Cornwall the tin ore is found in mineral veins, associated with copper ore, and traversing granite and slate rocks, when it is called *mine-tin* ; or scattered in crystals through alluvial deposits, as at Banca, when it is

known as *stream-tin*. Oxide of tin is also found in the granite and slate rocks, disseminated in small crystals. The principal ore is the peroxide of tin.

The usual method pursued in a search for veins, or lodes,* is to sink a shaft to a certain depth, and then to carry a *cross-cut*, or tunnel, north and south, so as to meet with every vein in the tract through which it penetrates. A lode having been discovered, a license from the proprietor of the soil, or "lord," must be obtained. As his share, or *dish*, he receives about an eighteenth of the ore raised; the remainder being divided, according to agreement, among the "adventurers" or workers of the mine. At the end of six or twelve months, the license is converted into a lease.

In working a mine, the three great objects to be provided for are—(1) the discharge of the subterranean water, (2) the removal of the "deads," or rubbish, and (3) the raising of the ore.

For the convenience of drainage an *adit*, or gallery, is begun in a neighbouring valley, and carried *up* to the vein, so as to secure the lowest possible level for the reservoir into which the water is to be pumped. The pumping-engines employed are of colossal size, are constructed on the high-pressure system, consume a comparatively small amount of coal, and are so simple in mechanism that they can be managed by a boy. The interior is always "handsomely fitted," clean, and well ventilated. To the main-beam is attached a *counter*, which, by registering the number of vibrations made in a given time, indicates the amount of work, or *duty*,

* The following remarks will apply to copper as well as to tin.

performed. This amount is arrived at by finding the number of pounds weight which the engine lifts one foot high by the consumption of one bushel of coals. In Austin's engine, on the Fowey Consols Mine, it exceeded in one year 87,000,000 lbs. The beam of the engine is connected with a rod which, through a chain of pumps, descends to the *sump*, or bottom of the mine, where the water collects, and thence a certain quantity of water is brought to the surface, and the rest to the adit, down which it gently flows to the neighbouring valley.

In some cases these subterranean water-channels extend to a considerable distance. Thus, the *Great Adit*, which drains some of the principal mines in the parishes of Gwennap and Redruth, is calculated, with its ramifications, to measure nearly thirty miles in length. The quantity of water discharged from a single mine occasionally amounts to more than 1600 gallons in a minute; and 37,000,000 tons have been pumped from the earth by about sixty engines in the course of a year. For instance, Davy's engine, in use on the Consolidated Mines, Gwennap, pumps directly from a depth of 1600 feet; the pumping-rod is 1740 feet long,—or, in other words, a third of a mile,—and lifts at every stroke 33½ gallons of water to the adit level, and 45 gallons more to the surface.

To return to the mine. The shaft having been sunk in the rock, a machine called a *whim* is erected, to bring up the deads and ore. This is a hollow cylinder of wood, or *cage*, revolving on a perpendicular axis, and worked by a steam-engine, or, in a small mine, by horses. As it rotates, the rope encircling it alternately coils and

uncoils, and raises one bucket, or *kibbal*, to the surface, while the other is lowered into the pit.

The shaft is generally rectangular in shape, measuring about six feet by twelve. It is divided in the centre by a stout timber partition, so that there are really *two* shafts—one for the use of the miners, the other for raising the ore.

The veins, or lodes, which it reaches, have been compared to “leaning walls” enclosed in the solid rock, slanting or *underlying* to the right or left, and descending to unknown depths. Where the shaft intersects them, *levels* or galleries, about six feet high and four feet wide, are driven horizontally along their course, one below the other, at intervals of from ten to twenty or thirty fathoms; and if these should be extended to any considerable distance from the original shaft, it becomes necessary, for the purposes of ventilation, to *sink* another shaft, which is made, like the first, to strike across the different levels. In the intervening space, a communication is also frequently opened up between two galleries by a partial shaft called a *wins*. More lodes than one are generally worked in a mine; the levels running parallel to each other at a uniform depth, and communicating by *cross-cuts*, driven through the intervening rock, or “country,” as it is called. The excavations are mainly effected by blasting with gunpowder, and the annual cost of the quantity consumed in the Cornish mines is stated to be £18,000 to £20,000. It is not usual, we are told, to extract all the ore which can be obtained. Certain portions are left against “a rainy day,” a season of ill-luck and unproductiveness; these,

the "eyes of the mine," are picked out only under pressing circumstances. The surface of the mine is called the *bal*, and a name is given to every separate shaft and level. In large speculations, a share of the profits is devoted to the purpose of further "discovery;" and, in this way, the solid rock, or "country," of the Gwennap Consolidated Mines was tunnelled, in about twenty years, a distance of sixty-three miles, at a cost of £300,000. In his subterranean explorations, the miner displays a really wonderful amount of skill. The cross-cuts are driven by the guidance of a compass,—a process which is known as "dialling;" and a shaft is frequently opened up at different depths, and "cut" with such perfect accuracy, that the various parts, when completed, meet together so as to form one vertical excavation.

The miners are divided into two great classes—*underground* and *surface men*; the former being, as compared with the latter, more numerous in the proportion of three to one. The underground men are divided into *Tulmen* and *Tributers*.

Tulmen sink the shafts and drive the levels and adits,—executing their work by the piece, which is generally calculated by the fathom, and earning on an average from sixty to seventy shillings per month.

Tributers find the ore, and raise it to the surface.

A gang of these men, whatever their number, undertaking the working of a particular portion of the vein, is known as a "pair." This pair is subdivided into three gangs, which, by relieving each other at the end of every "spell" of eight hours, carry on the work continuously, except on a Sunday.

The adventurers defray all the cost of sinking shafts and boring adits ; but the working of a limited part of the lode, called the "pitch," is let by auction on "settling-days," and taken by the miners on a two months' lease, the miners agreeing to find their *tribute*—that is, tools, candles, and gunpowder, an advance being made to them of "'sist money." They undertake also to open the vein and raise the ore, on condition of receiving a share of the proceeds, the amount being determined by the value of the ore when ready for market, and varying from 6d. to 13s. 4d. in the pound, according to the richness of the lode. Thus, the tributers are, to a certain extent, speculators ; and the fascination of this mode of adventure prevails over the dangers and hardships of their subterranean life, and induces them to embrace it with positive ardour. The surface-men attend to the machinery, and make ready the ore for market ; many of the operations, however, being performed by girls and women, whose lively chatter and bright-coloured dresses relieve the dulness of the scene.

As soon as the ore is raised to the surface, it is *spalled*, or broken into small fragments, and then pounded in the *stamping-mill*, so as to separate the peroxide from the gangue in which it is embedded.

The stamping-mill consists of a number of "lifters," or beams of wood armed with heavy iron extremities, which are raised and lowered by means of *cams* arranged on a barrel, or shaft, the latter being set in motion by a turbine or steam-engine.

These lifters pound or stamp the ore small enough to

pass the perforation of an iron grate, through which a stream of water carries it into a series of pits, the particles being deposited according to their specific gravity. The richer and heavier portions, called the "crop" or "head," collect in the first pit, and the slime or "tail" in the others. The crop ores are then removed to the "buddle," a pit in which they are arranged on an inclined timber frame called the "jagging-board," from which they are again washed by a run of water, and separated into three or four parcels of different value. The "head" or "crop" of these deposits is next thrown into the "keeve," a large vat containing water, and is further cleansed and purified by an operation called *tozing* or *tossing*. The water is rapidly stirred with a small shovel, so as to bring the *tin-stuff* into a state of suspension, when the "tozer" relaxes his efforts, and by frequently striking the keeve with a mallet, the tin, owing to its greater weight, sinks to the bottom, or is *packed*, while the earth and other impurities circle at the top, and can be removed. The deposit in the keeve is divided into two or three parts, the lowest of which is fit either for *smelting*, or, if associated with "mundic,"—a name the miners have given to arsenical and iron pyrites—for *roasting* in the "burning-house."

This is a "reverberatory furnace" fed with coal; but previous to the beginning of the eighteenth century, the dressed tin-stone was carried for smelting direct to a blast-furnace, supplied either with turf or charcoal. It was called the "blowing-house," and was commonly burned at the end of every seven or eight years for the

sake of the tin which had been carried up the chimney, or had collected in the thatched roof.

After "roasting," the crop ores are again buddled, tossed, and packed, until quite ready for smelting. The various separated portions, the "creases," "skimpings," and "leavings," are subjected to numerous similar operations—namely, *sifting*, *dillicing*, *tying*, *jigging*, *trunking*, and *framing*; all of which are conducted with the object of arranging the particles of ore according to their



specific gravity and relative value by the aid of water, and are described as "highly interesting on account of the dexterity exhibited in their performance." The tin ore, when thus prepared, is called "block tin," and is ready for sale. It contains 75 per cent. of metal; but when first brought to the surface, has frequently no more than 2 per cent. in it.

The mode of "dressing" copper ore is, in many of the operations, similar to that of tin. It is first broken

up with hammers, and the best part, or "frills," divided into fragments about the size of a walnut, by girls called *cobbers*, or crushed separately by cast-iron rollers. The second kind, the "dredge" ore, is crushed, and then treated in a sieve, called the "jigging" machine, which is jerked up and down in a "keeve," or hutch of water. The purest, named *halvans*, is either stamped, like the tin ore, or crushed, and then concentrated with the poorer parts and refuse of the former classes, in *buddles*, either round or rectangular, or in *strakes* and *tyes*, according to circumstances; while the *slime*, or that which has been reduced to the state of mud, is treated in *trunking buddles*. The various kinds, when sufficiently "clean," are arranged in heaps on the surface of the mine, and weighed into "doles," or parcels, for sale.

The ores of tin and copper, when thus prepared, are sold upon "ticketing days,"—that is, at the auctions which are held twice a month at Redruth or Treloweth for tin, and weekly at Truro, Redruth, or Pool for copper.

The agents for the companies who purchase the ores, having previously received samples of the different lots, and assayed them, meet the mining agents at a dinner—the expense of which is defrayed by the "mines" engaged in the transaction—and deliver sealed *tickets* containing their offers for the various parcels. These tickets are duly opened and read aloud, and the highest biddings accepted.

The affairs of a mine are under the control of a general manager, the *purser*; but the working is superintended by a *captain*, who, in large adventures, is assisted

by *grass captains* and *underground captains*,—the former superintending the operations on the surface, the latter the subterranean works.

The miners are described by a recent writer as an intelligent body of men, their wits being sharpened by the system of tribute-work, which renders their profits in a great degree dependent on their keenness and accuracy of observation. They are athletic and good-looking, but suffer very severely from pulmonary complaints. Their habits are generally remarkable for sobriety, moderation, and orderliness. They are mostly Wesleyans, and many of them are men of strong religious character—field-preachers, and regular attendants at revivals and prayer-meetings.

The mines of greatest interest to the traveller are those which, in the vicinity of the Land's End, penetrate under the sea ; for in these, when the Atlantic is dashing its huge rollers on the iron-bound coast, he may hear the harsh grating of rocks ground to and fro in the vexed ocean-bed, and the solemn reverberation of the tumultuous waves. It has been well remarked, however, that the enjoyment of sounds so portentous, though sublime, requires no ordinary strength of nerve in the visitor, since the din is frequently so terrific as to scare the veteran miner from his work.

Let us direct the reader's attention to the celebrated *Botallack Mine*, which is situated about fifteen miles from St. Ives and two miles from St. Just, and within a mile and three-quarters of the precipitous headland of Cape Cornwall.

Here cliffs of granite are masked by walls of slate, the remains of huge masses which the sea has washed away ; and precipitous crags of gray and purple are broken up into every conceivable form of ruggedness. The spectator stands astonished at the spectacle of large steam-engines, a stamping-mill, and all the heavy machinery of a mine planted among these crags, in what at first sight appear to be inaccessible situations. All is noise and bustle. Those descending "kibbles" go down to depths fathoms beneath the sea. In some places, says Mr. Walter White, the miners, tempted by the rich ore, have dug away the rock until not more than six or eight feet intervene between the galleries and the water. Once, indeed, the sea *did* break in, but it has been plugged out.

We went first, says Mr. White, to the platform on the summit of the cliff where the ore is drawn up. Standing here, at a height of three hundred feet, a striking view is obtained of the extraordinary scene, accompanied by a slight sensation of insecurity, as the strokes of the labouring engine vibrate through the wooden stage. Below, where the mighty pumps pursue their incessant labour, you mark a turbid red torrent tumbling into the sea, spreading its discoloration around on the waters in great clouds that diminish into curious tints where they mingle with the green. The contrast is singular between the red foam and the white, as the breakers leap on the foot of the cliff ! The rocks, too, are red in places, and the platforms and the paths,—all owing to a slight mixture of iron with the ore ; and you wonder how the women engaged in washing and sorting keep themselves so clean.



BOTALLACK NINE, CORNWALL.

We now descend to a lower platform.

Here we meet with far greater supplies of ore. Every minute the heavy heaps from below are poured out from the ascending kibble, and men wheel it away to larger heaps, while more women, and boys, and girls, pick and separate the various qualities ; all of them red, says Mr. White, and all busy, for here the labour goes on as in a factory. "I could not help thinking," he adds, "of those deep down in the underground darkness by whom the industry was maintained ; theirs the rudest task. The ore was coming up in great abundance, and of excellent quality ; and every one was, in consequence, in excellent spirits : and then there was the free air and bright sunshine."

Ever you hear the din of the heavy stampers, the gush of the pumps, the clang of machinery, and the continuous surge of the sea below. There are tramways, too, and trains of waggons running to and fro, and men and boys clambering up and down steep paths, apparently almost impracticable for a goat.

Our next stage in the descent is Crown Rock, on which stands another engine,—one of the largest in Cornwall. It could only be got into position by lowering it two hundred feet from the summit of the cliff. "Watch with what deliberate movement it works the pumps, and you will have an idea of its tremendous power. How amply it maintains the red torrent pouring into the sea. Walk round it, and look up. The scene is still more astonishing than when viewed from above. You no longer see the breadth of the crags ; and the sheds, the waggons on the tramways, the offices of the overlookers, and the

great beams of the machinery appear more as if growing out of the cliff than resting on its projections."

At Levant Mine, about a mile to the east, and at others near Cape Cornwall, there are similar combinations of machinery, and crags, and galleries under the ocean-bed ; but Botallack is considered to be that which best repays a visit.

Botallack is now worked by means of the Boscawen shaft, which was commenced in May 1858, under the following circumstances :—

A year or two previous, on driving the one hundred and eighty-five fathoms level north of Wheat Button shaft, and about three hundred fathoms distant from it, the entire length of the level being under the sea, a vein of copper was discovered, which, from its dip corresponding with that of the deposit on which they were then engaged, and from the similarity of the strata, induced the agent to conclude that they were on the "head" of another rich bed or branch of copper. Like true miners, they began to probe the ground ; and having thoroughly satisfied themselves, they made the following report to the "adventurers," or lease-holders of the mine :—"We suggest the propriety of sinking a diagonal shaft from the surface, so as to reach the present end of the one hundred and eighty fathoms level. The shaft will have to be carried about thirty-five degrees from the horizontal line, and the distance will be about three hundred and sixty fathoms. This, we think, can be done in as little time as, and with less expense than, sinking the present shaft, driving the level, and sinking wings for ventilation."

In accordance with these recommendations, the necessary engineering works were undertaken. The shaft was commenced, and from twenty to fifty men were employed in rising and sinking from the different levels to communicate the shaft; and on the 22nd of March 1862 the first tram-waggon laden with copper ore was drawn to the surface.

This shaft measures eight feet in width by six feet in height; and although in some places its angles are abrupt, and it winds considerably, yet the same underlay of 35° is everywhere observed. The rails have been laid down with so much skill and success, that little or no motion is felt in ascending or descending in the waggon,—which can accommodate six to eight men, and will hold nearly a ton of ore. The present length of the shaft exceeds two thousand four hundred feet, or nearly half a mile; and though it has not been carried through much solid ground, yet it has cost about £5 per yard, or £4000. Apart from the difficulties of sinking the shaft were the removal of the 24-inch cylinder engine, and the erection of a house to receive it. All who saw that tremendous machine lowered, some years ago, over the face of the precipitous cliff, one hundred and fifty feet in height, concluded that where it was then planted it must for ever remain. Yet some of them were present to witness the colossal cylinder and its beams raised to the brink of the cliff, and again lowered to its new position.

The Cornish mining-district has its special character, like the “Black Country” in the Midlands, or the region of flaming furnaces round Coatbridge and Airdrie. Taking Camborne as your centre, all round the horizon, except

where the Bristol Channel comes in, you see mines : a sterile landscape, everywhere rendered hideous by small mountains of many-coloured refuse ; traversed in all directions by narrow paths and winding roads, by streams of foul water, by screaming locomotives with hurrying trains ; while wheels and whims, and miles of pumping-rods, whirling and vibrating, and a forest of tall beams, develop a complete labyrinth of machinery and motion. Giant arms of steam-engines swing up and down, and the stamping-mills apparently seek to out-thunder one another, as they proclaim afar the successful progress made in disembowelling the bountiful old earth.

Mr. Walter White has some just remarks on the population, to whose labour this singular and impressive spectacle is due. The marked intelligence gleaming in their eyes, and their general expression, denote, he says, a habit of thinking for themselves, as you will find by their shrewd remarks, if you join in conversation with them. In daily conflict with rude circumstances, their native resources are developed and multiplied. Their ingenuity is shown in the numerous improvements they have effected in their tools and machinery. They will pierce a shaft in two or three divisions,—one party working from the surface, another from one of the uppermost galleries, and a third from the deeper workings,—yet, when complete, the three several portions will unite in a true perpendicular. It may be said of them, however, that they are always face to face with death. It has been estimated that one-half of the miners die of consumption between the ages of thirty-five and fifty. Some are killed, every year, by falling from the ladders in their ascent or descent ; numbers are

maimed by the daily blastings, which consume three hundred tons of gunpowder annually. In Gwennap the deaths by violence are one in five. In Union Mine, in the same parish, one of the levels could be worked only when the wind blew from the south, or south-east ; and whenever a change occurred at the surface, the men were forced to run for their lives, to escape a deadly gas that then issued from the fissures of the rock. The evil was eventually remedied by opening up a communication with the shaft.

The temperature at the bottom of the Union Mine ranged from 104° to 110° , and yet in this sultry and oppressive air the miners were forced to work. A stream of water at 98° ran through the same level ; and an attempt was made to mitigate the heat, by pouring in at a few yards' distance a stream of cold water, which lowered the temperature near it fourteen degrees. The men, who worked naked, would rush from the end of the level, stand for a moment or two under the refreshing douche, and then hasten back to their labour.

To climb three hundred fathoms of ladders after toil so exhausting, must be terrible. In the larger mines, however, "man-machines" have been introduced,—platforms affixed to rods, which rise or fall twelve feet at every stroke of the engine, and carry the men up or down without any exertion on their part, but that of stepping from one platform to another as they meet. In this way a descent of one thousand seven hundred feet may be accomplished in five and twenty minutes.

We may now turn to the subject of Gold ; and yet it has so frequently been discussed, and so much has been

written about gold-mines and gold-diggings, that we are afraid of wearying the reader.

There seems good reason to believe that, in earlier days, gold and silver existed in considerable abundance on the soil of England. As late as the reign of Edward II., between three and four hundred men were employed at Combemartin, in Devonshire, in the gold-mines ; and the product of those mines was afterwards of great assistance to the Black Prince in his campaigns in France. Gold has been found, and still is found, in several other parts of the United Kingdom, and especially in the county of Wicklow, in Ireland.

Its discovery occurred about 1796; and soon spreading abroad, the entire rural population of the neighbourhood, neglecting the cultivation of the crops, hastened to share in the gold-harvest. For six weeks the crowd enjoyed possession of the ground, and collected a considerable quantity of the virgin metal. Then the Government interfered, and resolved to establish regular works. By Act of Parliament, this enterprise was placed under the control of three directors. At first the produce of the mine defrayed the cost, and even left a profit ; but the works were suddenly interrupted by the rebellion of May 1798. In 1801, the works were resumed, and trenches opened in the solid rock to lay bare the auriferous deposit ; but, strange to say, the precious treasure had altogether departed. The total amount of gold collected by Government did not exceed above nine hundred and fifty ounces, representing a sum of about £3700.

Silver also has been frequently discovered in Great

Britain. In 1296, Edward I. removed from Devonshire seven hundred and four pounds weight of this metal; and up to the reign of George I., the Welsh mines furnished the bullion for a certain quantity of silver coins struck at the Mint. The mines of Aberystwith obtained quite a reputation about the end of the sixteenth and the beginning of the seventeenth century. These, it is said, furnished Sir Hugh Middleton with the noble fortune which he nobly expended in bringing the New River from Ware to London. On his death, they were purchased by a Mr. Bushell, secretary to Lord Bacon, and they yielded him a satisfactory profit. Having secured from Charles I. the privilege of coining money, he erected forges at the spot; and, in his loyal enthusiasm, clothed the king's army with part of the silver extracted from the mines, and converted by himself into legal coin. Moreover, he raised a regiment of miners at his own expense, and fought gallantly under the royal standard. But Aberystwith Castle being captured by the soldiers of the Parliament, the mines were abandoned, and have never since been worked.

Silver, at present, is obtained in no inconsiderable quantity from our lead-mines, by means of an ingenious process, invented by Mr. Lee Pattinson. About seventy thousand tons of lead are raised in Great Britain yearly, and more than one-half contains a certain proportion of silver.

Our principal supplies of gold are now obtained from California and Australia, the mines of Mexico and Chili being in a state of decadence. The resources of California

were first thrown open to the world in 1848, and their discovery produced an excitement in Europe and the United States which was not inaptly termed the "gold-fever." In less than six months five thousand English-speaking adventurers flocked to the new Dorado. But, so far as Great Britain is concerned, the sensation was still stronger and more general when it was known that gold existed in Australia. It was felt that England was about to have a California of her own, gold-fields over which would fly the Union Jack. She who, as Esquiros says, had hitherto received the precious metal from foreign countries, was now about to send her own into the European markets. And then the discovery was wholly and completely English; it had emanated from the London scientific societies. So far back as 1844, the late illustrious geologist, Sir Roderick Murchison, after examining specimens of rocks collected by Count Strzelecki on the eastern chain of the Australian mountains, had exclaimed, as he placed his finger on the map, "Were a search made here, gold would be found."

This scientific forecast was repeated by the Australian journals; and in 1849 a certain Mr. Smith presented himself at Sydney with a nugget of native gold before the members of the Colonial Government. He offered to point out the spot where he had discovered the specimen, and where the precious metal abounded, if the Government gave him a liberal reward. The Government refused, for there was no proof that the nugget had not been brought from California, and they felt unwilling, by any rash action, to excite a gold-seeking mania. Mr. Smith, therefore, was invited first to indicate the locality

of the gold-field which he wished to sell, and to trust for the rest to the generosity of the Government.

Mr. Smith withdrew, carrying with him his secret; but the story soon got noised abroad. Another and more patriotic colonist, Mr. Hargreaves, who had acquired some knowledge of mining in California, gained, in 1851, all the honours of the discovery, and, as he made no stipulations, received the Government reward. The site of his discovery was Conobolas, about thirty miles west of Bathurst. It is almost needless to say that immediately a violent excitement spread throughout the colony of New South Wales, and rapidly extended to that of Victoria, and to regions still more remote. In the first week of July 1851, an aboriginal inhabitant, in the service of Dr. Kerr, of Wallawa, discovered, while tending his sheep, a mass of gold among a heap of quartz. Three blocks of quartz (from two to three hundred-weight), found in the Murroo Creek, fifty miles to the north of Bathurst, contained 112 lbs. of pure gold, valued at £4000. The "Victoria nugget," a noble mass of pure gold, weighing 340 ounces, was brought to England from the Bendigo diggings. From the gold-fields of Ballarat and Mount Alexander, in the colony of Victoria, up to October 1852, 2,532,422 ounces were found (or 105 tons 10 cwt. of gold); and the precious metal exported up to that date represented £8,863,477. Some idea of the wealth of the Australian "diggings" may be formed from the fact, that in ten years New South Wales and Victoria sent to England gold to the value of £96,000,000.

Gold was discovered in New Columbia in 1856; in



SCENE IN THE AUSTRALIAN GOLD-DIGGINGS.

New Zealand and Nova Scotia in 1861; in Sutherlandshire in October 1868, but the supplies were soon exhausted; in West Australia in 1870; in the Bendigo fields, Victoria, in November 1871.

The annual produce of gold, throughout the whole world, is now between £30,000,000 and £40,000,000 sterling. Wherever the precious metal is found, its origin may usually be traced to quartz veins occurring in the primary or igneous rocks, such as granite, gneiss, porphyry, clay-slate, or greenstone. As these rocks are decomposed by atmospheric action, portions of the auriferous veins are swept down by streams and floods, and so find their way into the deposits of clay, sand, and gravel in river-beds, and in the hollows and gullies of the hills. Gold is commonly met with in small scales, or grains, called gold-dust, but sometimes in lumps or nuggets of a considerable size. The largest known was the so-called "Welcome," discovered at Ballarat in 1858. It weighed 2166 ounces, and its value was £8376, 10s. 10d.

In Europe the most celebrated mines are those of Hungary and Transylvania, which produce every year about £300,000 worth of this metal. Gold is also worked, though on a small scale, in Spain and Piedmont. The extensive auriferous region of Eastern Siberia, which yielded so abundantly in 1842 and following years, seems now to be exhausted.

The most important properties of gold may be briefly stated. In its native state, it is distinguished by a peculiar yellow colour, and high metallic lustre; is nearly as soft as lead, and is the most malleable of all metals.

It is capable of being beaten out into leaves of a thinness not exceeding $\frac{1}{280,000}$, or, according to some authorities, $\frac{1}{280,000}$ of an inch, through which light is transmitted with a green tint. In this way one grain may be spread over fifty-six superficial square inches ; while the ductility of the metal is so great, that the same quantity may be drawn out into five hundred feet of wire.

It is inferior in tenacity to iron, copper, silver, and platinum ; but a wire with a diameter of 0.787 (or rather more than one-third) of a line (which is one-twelfth of an inch) will support a weight of 150 pounds.

Gold fuses at about 2016° , according to Daniell's pyrometer ; and when in fusion, exhibits a bluish-green colour. It is scarcely at all volatile in the heat of the furnace, but is dispersed into purple vapours by the agency of a powerful electric discharge, or by the concentration of the solar rays through a strong burning-lens. It is unaffected by exposure to the atmosphere, by alkalies, and by all the simple acids, except selenic ; but it is dissolved by any mixture which evolves chlorine, the solvent usually employed being *aqua regia*, or one part of nitric acid mixed with four parts of hydrochloric acid. It is a wonderfully perfect conductor both of electricity and heat. Its specific gravity is less than that of platinum and iridium, ranging from 19.2 to 19.4, according as it is fused or hammered.

To these qualities, as well as to its comparative scarcity, is due the high estimation in which it has been held from the earliest times. It is the "king of metals."

Silver is also a metal of great value, and, like gold, has

always enjoyed an extensive reputation. It is the whitest of the metals, and can be made to receive a lustre scarcely less brilliant than that of highly polished steel. In its burnished state it reflects light and heat more powerfully than any other metal, so that it has an inferior capacity of radiating heat,—and hence a silver vessel retains the temperature of the liquid contained in it longer than a vessel of any other metal. In malleability and ductility it ranks next to gold. Its density is 10.47; it is harder than gold and softer than copper; when pure, it is so soft that a knife can cut it; the addition of a small quantity of copper increases its hardness; it fuses at 1873°.

There is a large demand for silver, says Tomlinson, not only for the purposes of coinage, but also for services of plate, and, it may be added, for ornamental and decorative work. For the table it is admirably adapted, inasmuch as it is not attacked in the slightest degree by any of the substances used for human food. This large demand is met by a comparatively abundant supply, the metal being found both in the native state, and alloyed with various other metals; also, mineralized by the non-metallic elements, and in combination with certain acids.

Native silver accompanies the other ores of this metal, particularly the sulphuret and the chloride; it occurs either in the crystalline or the arborescent form. We meet with it also in amorphous masses, one of the largest of which is preserved at the Copenhagen Museum; it weighs about 500 lbs., and was procured from the mines of Königsberg, in Norway. Sometimes native silver is disseminated in ferruginous rocks; and in the district

about Lake Superior in America, it is associated with malleable copper.

The native sulphuret of silver, or vitreous silver ore, occurs in various forms, and when crystallized is in cubes, octahedra and dodecahedra. Its colour is that of a shining leaden-gray. It is very fusible. One of the richest and most extensively distributed of the ores of silver, it supplies a large proportion of the demand. It is met with in Saxony, Bohemia, and Hungary, and is very abundant in the mines of Guanaxuato and Zacatecas in Mexico. It is often associated with the sulphurets of copper, iron, and antimony.

In Chili, one of the richest and most abundant ores is the chloride, which is often accompanied by native silver. It is found in massive amorphous fragments associated with the sulphuret, and also in small cubical crystals disseminated in the ferruginous rock known by the names of *pacos* and *colorados*. Its colour is white or yellowish-white, but changes, on exposure to the air, into violet.

From the precious metals we turn to Lead, which ranks high among the utilities, and is assuredly to be included among the treasures concealed "beneath the surface." It was well known to, and in extensive use by, the ancients; and during the Roman occupation of Great Britain our lead ore formed an important article of commerce. Blocks or pigs of lead have been discovered with Latin inscriptions engraved upon them; and the remains of Roman stations, villas, and cemeteries have been exhumed in the neighbourhood of the mines. After the Roman eagles had left us, the Saxons and the

Old-English continued to work the mines,—one of which, near Castletón, was dedicated to Odin. Those in the vicinity of Wirksworth have been in operation since, at least, the year 714; for we read of a sarcophagus of lead, lined with linen, as having then been prepared in this locality. In Domesday Book the Derbyshire lead-fields are included among the demesnes of the Crown.

In the United Kingdom lead is found and worked in Allendale and other parts of the west of Northumberland; at Alston Moor in Cumberland; in the west of Durham; in Swaledale, Arkendale, and other parts of Yorkshire; in Staffordshire, Cornwall, the Mendip Hills of Somersetshire; the Isle of Man; in the Welsh counties of Flint, Cardigan, and Montgomery; in the Irish counties of Wicklow, Waterford, and Down; and in the Scotch counties of Ayr, Kirkcudbright, and Lanark. But the most extensive and profitable are those of Northumberland and Derbyshire. The average annual product of lead in Great Britain is about 65,000 tons.

In Derbyshire the principal ores occur in the mountain limestone, and consist of sulphuret of lead, massive foliated lead ore, steel-grained lead ore, slickenside (a variety of the sulphuret), white lead ore (a dull-coloured sulphate), and phosphate of lead.

In Northumberland the chief seat of the lead industry is Allendale; and the capital of Allendale is Allenheads, one of the most elevated places in England, situated 1400 feet above the sea-level. It lies, however, in the very bosom of lofty hills, which shelter it from the keener blasts.

The miners' wages, in this district, vary from fifteen to

twenty shillings a week; payment is made by an advance of two pounds "subsistence money" every four weeks, and the balance once a year. In contrasting the amount with their labour, says Mr. White, we must bear in mind that the miners' day is but eight hours, and for five days only in the week. Hence, if so inclined, they have ample leisure to work in their gardens, meadows, or fields. Mr. White informs us that their great ambition is to possess a little freehold, and many of them save money enough to accomplish their desires; and you may see their cottages scattered on the hillsides, with cheerful patches of green around them.

The same traveller descended the Allenhead mine. "It was almost like going down a well," he says, "to descend the shaft, so copious is the drift from the sides. The depth is seventy-seven fathoms, but we stopped at a level—or 'random,' as the miners call it—forty-two fathoms down, and there getting into a narrow waggon, each holding a candle stuck in a lump of clay, were driven away at a trot to 'the west end of Harry.' If you feel crushed in a coal-mine, much more so here, where the ways are so narrow—but little wider than the waggon—and you must sit still if you would avoid bruising your head against the limestone. Having rattled on for a mile and a half, I learned that Harry was the name of a vein: and here we got out and walked, and I saw how the vein of lead had been in places eight or nine feet thick, how it thinned off in places to an inch or two, in places to nothing, and was only traceable by the black line in the rock where the smooth shining surfaces come together, known to miners as *slickensides*. I saw veins

of fluor-spar, intersected by threads of metal, and the various strata—limestone, shale, and clay, and in one of the veins a number of cavities full of beautiful crystals; wondrously beautiful they looked in the candle-light, like fairy grottoes. We crawled at times on hands and knees; we climbed and descended perpendicular ladders twenty fathoms or more, through openings so narrow, that with an inch or two additional breadth of shoulder you would stick. 'Tis grievesome wark,' said an old miner who came panting up one of these chimney-like passages; 'but that was aye a weary way-gate.' And so we came to the 'forehead,' or one of the utmost extremities, where the men were working naked to the waist, and the heat and closeness were sickening,—at least, to my unaccustomed senses. We spent three hours in this subterranean travel; then we returned to the waggon,"—and Mr. White once more sought the free light and fresh air of day.

Another district in Northumberland, famous for its lead-mines, which was visited by the same enterprising traveller, is Nent Head, four miles from Alston. This village, indeed, as Mr. White informs us, makes no secret of its vocation; for huge mounds of refuse, tramways, waggons, piles of ore, implements scattered in all directions, and a sturdy population, proclaim that it lives by the mines. It belongs to the London Lead Company, who rebuilt it some years ago. From all signs of poverty it is free, but there are abundant signs of work: men and boys washing, sorting, and crushing ore, amid the splashing of water, the thumping of machinery, and a clatter as

of falling stones when the waggons from the mines deposit their burden. From the heaps of ore at one end of the industrious little colony, to the slime-pits at the other end, the genius of labour reigns triumphant.

Nent Head is situated near the summit of the valley of the Nent ; the smelt-mill, where the ore is roasted and melted, and cast into pigs of lead, is situated still higher. The process of roasting is as follows :—The ore is spread on the sole or floor of a furnace, and heated to a very high temperature, until, though it does not melt, it throws off its sulphur, and takes up oxygen. In another furnace it is melted, and you see the molten stream flowing from the mouth into a pot. In a third, the stubborn slag, or the dross and refuse, is treated by a roaring blast until it becomes tractable, and yields every particle of lead, while splendid blue and green flames leap and play in the impetuous current. Even the sweepings of the chimney are converted into metal by the action of fire. Silver is separated from the baser and duller lead. But among many wonderful sights, not the least wonderful is the huge water-wheel, of truly colossal dimensions, which drives the condensing apparatus.

The village, as we have indicated, lies on a hill slope ; and here and there you see the galleries, or entrances to the mines, which penetrate the hills for miles, ramifying and honeycombing to such a depth that they reach the diggings from the other side,—and it is said to be possible to strike seven miles underground, and come out in Weardale. One of the entrances opens on Rampgill vein, from which seventy-two tons of ore have been dug weekly for upwards of a hundred years.

The subject of this volume is "Beneath the Surface." Will the reader think we depart too widely from it, if we proceed to examine the works, and the processes by which lead is produced?

In our examination we must follow the guidance of Mr. White, for we cannot speak of the Lead Industry, as we can of the Coal, from personal knowledge.

When the ore comes from the mines it is in rough stony lumps, of all sizes, from the bigness of a man's head down to a grain of sand. Some lumps are slaty in appearance, resembling quartz; others are good specimens of the pale gray limestone from which they were torn: and the more they all sparkle with crystals of lead, the better is their quality. Some look as if they were *all* lead, only brighter, so cunningly is the earth masked; and these, which are singularly heavy, the miners lovingly call "lazy lumps." The local term for ore is *ranse*. The waggons laden with it run from the mines to the works, where each drops its burden into the bouse-teams; that is, into a range of open compartments, according to quality. Here the ore lies ready to hand; the washing-floors are adjacent on the same level; and the next operation is to break it up, wash it, and separate metal from stone.

A barrowful of ore is thrown on an iron grating, which is exposed to a running stream of water. The light earthy and gritty particles are thereby washed off, and carried into the "trunk-box" placed in connection with the grating. Meanwhile men and boys stand by with hammers, and pick the washed lumps. That which is all stone is flung aside, the metallic lumps are broken up

and sorted, and as much of the alloy got rid of as possible, so as to make them ready for the next operations, "buddling" and "hitching," which may be described as a kind of sifting with sieves suspended in water. The heavy portions then sink to the bottom, where they lie, like a distinct stratum of *galena*, all bright and glistening, and ready for the smelt-mill.

Nothing, however, is lost at Nent Head. The washings are not allowed to run to waste, but are intercepted and made to give up whatever metalliferous fragments they may contain. From time to time the trunk-boxes are emptied, and the small lumps of ore carefully selected; in fact, all is done that can be done by ingenuity and skill to save lead. The water of the washings, prior to its final exit from the premises, is conducted into "slime-pits," where, for a time, it remains almost stagnant, until it has deposited the light particles held in suspension. These form thick beds of "slime," in which a considerable quantity of lead is contained. But how to separate it?—that is the question.

The mode adopted is very ingenious. An inclined plane is formed with two rollers, and an endless web of canvas. The web is set in motion, travelling, so to speak, up-hill, and while it moves the slime drops upon it from a trough; water falls at the same time in a brisk shower,—with this result, that as the web moves the particles of lead, owing to their weight, fall into a trough, while the fine sand and mud are washed away. Then, in a turbid stream, the water is dismissed. Even the lead-seekers have done with it.

Of the miners themselves, Mr. White says that they

are, for the most part, sober and industrious; there appears to be something in their metalliferous employment which makes them, as a class, more respectable than coal-miners. Go down to the Durham coal-field, visit and observe the mining-villages, and you will hear of coarse indulgences and brutal propensities that shock every sense of propriety, and make you shudder for human nature. Contrasted with that unhappy region, the lead-mining districts attain a very high standard of morality.

Referring for one moment to the general subject, before we pass on to treat of iron, we may observe that pure lead is not of very frequent occurrence. Nearly all the lead which forms the staple of our commercial transactions is obtained from *galena*, the native sulphide of lead, by the process we have attempted to explain.

The most abundant, and, on the whole, the most useful of the metals, is Iron, which, from the earliest ages, has played an important part in the history of nations. To our rich stores of iron we owe our commercial supremacy, and thence, by an obvious sequence of events, our power, our wealth, our widely-extended empire. Without iron there could be no machinery, and without machinery civilization would have remained as it was five centuries ago. The steam-engine, the railway, and all that has followed in their train, all the great political and social changes which they have inaugurated, all the mighty forces which are contained in and connected with them, could never have been. The country which, among its mineral resources, ranks an abundant store of this

truly precious metal, seems destined by the Providence which guides the course of history to attain a supreme position, and extend its influence over less favoured nations. The Lands of Iron prevail in the struggle for empire over the Lands of Gold.

In its native form iron chiefly occurs in meteoric stones, and in certain ores of platinum, and, consequently, is not very frequently met with; but the so-called iron ores, the oxides and sulphides, are very widely distributed.

Its value seems to have been understood at a very early period of the world's history. We read in Genesis that Tubal-cain was an instructor of every artificer in brass and iron, and references to iron are found in many parts of the Biblical record. Among the ancient Greeks, and probably in all nations, the age of bronze preceded the age of iron; but iron was well known in the Homeric age, and there can be no doubt that the allusion is to this metal in the famous passage in the "Odyssey":—"As when some smith or brazier plunges into cold water a loudly-hissing great hatchet or adze, tempering it, for hence comes the strength of *iron* (*αἰξήρος*)."
Steel weapons and implements were afterwards in common use in Greece. Æschylus includes all the countries on the shores of the Black Sea under the general term Scythia or Chalybia. The Chalybes he describes as "workers in iron," and Scythia as "the mother-land of iron." The sword he poetically characterizes as "sharp iron, the bitter appeaser of strife," and as "the Pontic stranger, born in fire." From this time dates the employment of the word *χάλυβς*, in Greek, to signify steel of the best

quality, whence it passed unchanged into the Latin language, and may at the present day be recognized in our own under the form *chalybeate*.

Iron was known to the Romans at an early period, and Æthalia (or Elba) was celebrated then as now for the richness and excellence of its ores. Pliny enumerates the various uses of iron in an animated passage, concluding with the exclamation, "We owe to it all the other necessities of this life." Spain was at that time one of the principal seats of the iron manufacture.

The earliest method of smelting iron seems to have been in furnaces erected on the summits of hills for the sake of currents of air, the furnaces being everywhere perforated with holes, through which the air was driven when the wind blew; the ore was laid between courses of charcoal, large quantities of which were added as required,—and the entire process occupied between two and three days. It is probable that a similar method was followed by the ancient Britons, who obtained their knowledge of iron-smelting, it is supposed, from the Phœnicians. As iron is mentioned among the exports of Britain by the geographer Strabo, it is obvious that the Britons must have been acquainted with the art of manufacturing iron prior to the epoch of the Roman Conquest; and we know this to have been the case, from the fact that they opposed their powerful invaders with broadswords, scythes, and spears made of iron.

No doubt, the Romans did much to improve the manufacture. In A.D. 120 a great *fabrica*, or military forge, was erected at Bath; and similar establishments, under the care of the *fabri acerrarii*, were soon formed in

other parts of the country. The evidences of Roman industry in working the British iron-mines are numerous: immense beds of iron cinders, or *scoria*, have been discovered in the Forest of Dean, in Monmouthshire, in Yorkshire, and elsewhere, as well as Roman coins, and the remains of altars dedicated to the god who presided over iron. These heaps are locally known as "Danes' cinders,"—from a tradition that the Danes, during the occupancy of England, carried on the art of iron-smelting extensively. Such relics are very numerous in Sussex. Many coins, Samian ware, and other articles, have been found in a cinder-bed at Maresfield; and Roman coins have since been discovered in cinder-beds at Sedlescombe, Westfield, and Framfield.

It is probable that the iron-mines continued to be worked by the Saxons. We read of Gloucester as celebrated for its iron-forges; and it is recorded in Domesday Book that no other tribute was exacted from it than thirty-six decails (of ten bars each) of iron, and a hundred iron rods for nails or bolts for the use of the king's ships. From the epoch of the Conquest down to the death of John, iron and steel were imported from Germany and other countries,—the German "merchants of the steel-yard" being so called from the article imported by them, and sold at a place called "the Steel Yard."

Wood charcoal was at this time, and for some generations later, employed in smelting iron, so that the woodland districts of the south of England were the great seat of the iron industry. Sussex, more particularly, acquired considerable wealth from its iron manufactures. A grant made by Henry III. to the city of Lewes empowered its

inhabitants to raise tolls for the repair of their fortifications, and every cart *laden with iron* from the neighbouring weald was to pay one penny, every horse-load one halfpenny. In 1290 we read of payment made to Master Henry of Lewes, for iron-work for the monument of Henry III. in Westminster Abbey. We read, too, that three thousand horse-shoes and two thousand nine hundred nails were supplied by Peter de Walsham, Sheriff of Surrey and Sussex, in the thirteenth year of Edward II., for the expedition against Scotland.

Most of the iron ordnance—made of bands of wrought iron—used in the French wars of the fifteenth and sixteenth centuries, were manufactured in Sussex. These hooped guns were superseded by cannon cast in an entire piece, and bored, as at present: of which the first was made at Buxted, in Sussex, by Ralph Hoge or Hogge in 1543. The Hogge family resided at Hog House, near Buxted Church. Their name seems to have become confounded with that of Huggett; since at Huggett's furnace, between Buxted and Mayfield, the first iron ordnance is reputed to have been cast. So runs an old local couplet:—

“ Master Huggett and his man John,
They did cast the first cannon.”

The iron industry continued to develop rapidly during the sixteenth century, involving a serious destruction of the noble forests which at one time overspread so considerable an area of Sussex, Surrey, and Hampshire. Henry VIII. and Elizabeth endeavoured, but in vain, to check the waste by legal provisions. John Norden,

writing in 1607, records that in Sussex alone nearly one hundred and forty hammers and furnaces for iron were in operation, each of which consumed from two to four loads of charcoal every twenty-four hours. Drayton, in his "Polyolbion," pathetically laments the disappearance of the "stately wood-nymphs" of the South :—

"These forests, as I say, the daughters of the Weald
 (That in their heavy breasts had long their griefs concealed),
 Foreseeing their decay each hour so fast come on,
 Under the axe's stroke, fetched many a grievous groan.
 When as the anvil's weight, and hammer's dreadful sound,
 Even rent the hollow woods and shook the queachy ground ;
 So that the trembling nymphs, oppressed through ghastly fear,
 Ran madding to the downs, with loose dishevelled hair.
 The sylvans that about the neighbouring woods did dwell,
 Both in the tufty frith and in the mossy fell,
 Forsook their gloomy bowers, and wandered far abroad,
 Expelled their quiet seats, and place of their abode,
 When labouring carts they saw to hold their daily trade,
 Where they in summer wont to sport them in the shade.
 'Could we,' say they, 'suppose that any would us cherish
 Which suffer every day the holiest things to perish?
 Or to our daily want to minister supply?
 These iron times breed none that mind posterity.
 'Tis but in vain to tell what we before have been,
 Or changes of the world that we in time have seen ;
 When, not devising how to spend our wealth with waste,
 We to the savage swine let fall our larding mast.
 But now, alas ! ourselves we have not to sustain :
 Nor can our tops suffice to shield our roots from rain.
 Jove's oak, the warlike ash, veined elm, the softer beech,
 Short hazel, maple plain, light asp, the bending wych,
 Tough holly, and smooth birch, must altogether burn ;
 What should the builder serve supplies the forger's turn,
 When under public good base private gain takes hold,
 And we, poor woful woods, to ruin lastly sold."

The Sussex iron varied considerably in quality. "Some," according to Camden, "was more brittle than the Spanish iron ;" but that wrought at the Ashburnham forges excelled in the property of tenacity, and Mr. Lower informs us, on the authority of some experienced men, that it was

in no wise inferior to the Swedish metal, generally accounted the best in the world. The site of an iron-work was selected near to beds of ore and to some available water-power. Artificial ponds were generally constructed by embankments thrown up against the stream, with an outlet of masonry for the supply of water, by means of which the wheel connected with the machinery of the hammer or the furnace was set in motion.

The trade reached its climax of prosperity in the seventeenth century; and even as late as 1724, the iron manufacture was still regarded as the principal interest of the county. But the decline had already begun, and after 1750 rapidly amounted to complete decay. The North was able to oppose to the South its combination of coal and iron, and iron and wood could not long withstand the competition.

It was in 1618 that coal was first used in iron-smelting. Like every other improvement, it met with considerable opposition, and gradually died out. In 1713 it was re-introduced by Abraham Derby in his furnace at Coalbrook Dale; and soon afterwards came, in swift succession, those remarkable developments of scientific industry which have raised the iron manufactures of England to their present position—namely, the invention of the modern steam-engine, by Watt, in 1770; the puddling and rolling processes of Henry Cort in 1784; and, more recently, the employment of the hot blast by Neilson, and Bessemer's admirable method of producing malleable iron and steel.

The following figures will show more plainly than any words the surprising growth of this important industry in Great Britain :—

IRON PRODUCED IN GREAT BRITAIN.

In 1740 by 59 furnaces.....	17,350 tons.
1788 „ 77 „	61,920
1796 „ 121 „	124,789
1802 „ 168 „	227,000
1806 „ 227 „	250,000
1820 „ 260 „	400,000
1825 „ 374 „	581,367
1840 „ 402 „	1,396,400
1848 „ 623 „	1,996,558
1852 „ 655 „	2,701,000
1855 „ 700 „	3,217,154
1857 „ 720 „	3,659,447
1865 „ 740 (?) „	4,819,254
1869 „ 760 (?) „	5,445,757

Iron ores are very numerous, but our limits preclude us from doing more than referring to the most important.

One of the most widely distributed is the *magnetic*: it occurs in granite, gneiss, mica-slate, clay-slate, syenite, hornblende, and chlorite, as also in the limestone formations. From this ore almost all the Swedish is obtained, and the Swedish iron is celebrated for its good quality. It abounds in the Isle of Elba and in the United States of America. Its primitive form is a cube, but it is often met with in octahedrons and dodecahedrons. It is brittle, of an iron-black colour, and leaves a black streak. Specific gravity, 5.0 to 5.1. Composition: iron, 71.78, and oxygen, 28.22. Or, peroxide of iron, 69, and protoxide, 31.

- *Specular iron; red hematite.* The crystals of this ore are generally of a dark steel-gray colour, opaque except in very thin laminæ, when they are transparent, and of a deep blood-red tinge. It leaves a reddish streak; its specific gravity varies from 4.8 to 5.3. Pure specular iron consists wholly of peroxide of iron.

There are several varieties of red iron ore. Fibrous iron, or red hematite, is found in fibrous reniform masses. If no signs of a columnar structure are visible, it is termed *compact*; and, if mixed with argillaceous matter, it is termed *red ochre*. When the structure of specular iron is foliated, it is called *micaceous*. Specular iron ore is also



IRON ORE.

known as oligistic iron, iron glance, and rhombohedral iron. The colour of jaspery clay iron ore is a brownish-red, with a large flat conchoidal fracture. When it occurs in small flattened grains, it is known as *lenticular clay iron*.

The purer varieties of this ore are found in the older formations; the argillaceous ores in secondary rocks.

Red hematite is found in reniform masses in Cornwall, at Ulverstone, in Lancashire, and in other parts of England.

Brown iron ore, as its name implies, is of a brownish hue. Its specific gravity varies from 3.8 to 4.2. In a pure state, it yields 55 per cent. of metallic iron. It is a hydrated peroxide, chiefly found in sedimentary rocks.

In some countries—as, for example, in France—this ore is the most abundant source of iron; and when washed to cleanse it of its lighter impurities, it supplies an excellent material for the manufacture of iron. But when, says Tomlinson, beds of oolitic or pea-iron are found to alternate with calcareous deposits, the metal produced is called “short,” in consequence of the phosphorus derived from the organic matter of the chalk.

Iron pyrites, or *bisulphuret of iron*, crystallizes in cubes, with a bronze-yellow colour, and a metallic lustre. This ore is brittle, and strikes fire with steel; whence its name, *pyrites*.

Passing over *chrome-iron*, which is found abundantly in the Shetland Islands, we come to the *carbonate*, from which most of the iron manufactured in this country is obtained. It occurs in rhombohedrons and six-sided prisms, resembling carbonate of lime; also in globular concretions, or lenticular masses. When pure, it consists of protoxide of iron 61.37 per cent., and carbonic acid 38.63. It is known by the various names of siderite sparry iron, spathose iron, brown spar, and the like. Sparry carbonate of iron often accompanies other metallic ores, such as those of lead and copper. In Styria and Carinthia the beds occur in gneiss; in the Hartz, in

grauwacke ; but all our English deposits are confined to the coal formation. As it is generally found embedded in schistous clay, more or less compact, which moulders away on coming into contact with the atmosphere, it is popularly known as clay ironstone.

Black-band, or carbonaceous ironstone, is also a carbonate of iron, containing carbonaceous matter in addition to the ordinary earthy matter found in all argillaceous ironstones. It is a sufficiently extensive deposit in Wales and Scotland.

We suppose that nowhere in the world can there be found so important and busy an iron-making district as South Wales. There the coal-field spreads over an area of eight hundred miles, and thus the two great industries of the most useful fuel and the most useful metal, coal and iron, flourish side by side. The number of blast-furnaces constantly sending up their seething flames and clouds of vapour exceeds one hundred and sixty, and each produces about one hundred and twenty tons of iron weekly ; while the annual production of coal may be estimated at six million tons. The Ebbwvale and Victoria Iron-works alone employ about nine thousand people ; the Dowlais upwards of sixteen thousand. The entire country, for miles around, is studded with evidences of mining activity : sombre-looking engine-houses at the mouth of yawning coal-pits ; networks of railroads and tramways ; coke-ovens, with their undulating lines of dull light ; and long stacks of chimneys incessantly pouring forth fire and white jets of steam.

The next great iron-producing district in the United

Kingdom is that of Central Scotland, and third in rank comes South Staffordshire. Inferior in yield to these are the iron-fields of North Staffordshire, Derbyshire, Shropshire, and the West Riding of Yorkshire.

Another very important district furnishes an ore belonging to a more recent formation than the coal-measures,—namely, the *lias*. This deposit, unknown thirty years ago, now produces upwards of four hundred and fifty thousand tons per annum. We allude to the ironstone of the Cleveland Hills, discovered in 1847. Deposits of ironstone have also been found in Leicestershire, and of brown iron ore in Northamptonshire, and some other parts of England. The pisolitic or oolitic ore, which abounds in Belgium, has been discovered by Mr. Rogers, of Abercarn, at the base of the carboniferous limestone of South Wales.

Turning from England to the Continent, we find large beds of iron in Sweden, where the Dannemora mines have attained a great reputation; in Belgium, France, Prussia, and Austria; and in the Ural Mountains. Extensive deposits are also worked in Canada, and several of the American states, as New Jersey, Pennsylvania, and Virginia. But the produce of the iron-mines of the British Isles is about equal to that of all other iron-producing countries taken in the aggregate. Iron and Coal are the two great staples of our prosperity, and the main elements of Britain's material greatness are thus to be found—
Beneath the Surface.



INDEX.

- ACQUA DI CASTIGLIONE, 139, 140.
 Adelsberg, grotto of, 275; Sir Humphrey Davy's description of, 276.
 Adige, the river, character of, 14.
 Ælian, quotation from, 361.
 Agnano, lake of, described by Dr. Daubeny, 127, 128.
 Aix-la-Chapelle (Aachen), mineral waters of, 198-200.
 Alabaster Cavern, in California, described, 339-343; quarries of, worked at Volterra, in Italy, 446-448.
 Allenhead, lead-mine at, visit to the, 537, 538.
 Alluvial deposits, nature of, 64, 70, 72.
 Alvarado, jet-d'eau, or leaping fountain, at, 191.
 America, principal mines of, 80; great mineral marts of, 95.
 Antiparos, description of the celebrated stalactitic grotto at, 292-299.
 Aqueous rocks, origin of, 13; principal divisions of, 16, 17.
 Arc, natural bridge of, over the river Ardèche, 291.
 Arcy, grottoes of, described, 306-309.
 Arenaceous rocks, nature of, 17.
 Arethusa, various fountains of, 173, 174.
 Argillaceous or aluminous rocks, nature of, 17.
 Artesian wells, construction of, 160; of Grenelle, 160; of Passy, 161.
 Ausonius, his reference to the fountain of Nîmes, 186.
 Avernus, lake, of the ancients, 124, 125; historic associations of, 125, 126; general description of, 126, 127.
 BALLACHULISH, slate-quarries of, in Argyllshire, 444.
 Balme, prevalence of the name of, 229; grottoes of, in France, described, 278-284.
 Balme, or Baume, as applied to caverns, 229.
 Barèges, mineral waters at, their properties, 198.
 Bath, city of, 202; its legendary origin, 203; its condition under the Romans, 203, 204; its later history, 204; its mineral waters and their properties, 204.
 Bayard, the French knight, anecdote of, 236, 237.
 Benieguazeval, volcanic cavern of, 248.
 Beranger quoted, 39.
 Bisson, story of Romain, 258-260.
 Bize, the bone-cavern of, 367.
 Bladud, legend of Prince, supposed founder of Bath, 202, 203.
 Blue Grotto of Capri, described, 219-223.
 Bochnia, salt-pits of, 105.
 Bone-caves and their deposits, description of, 47, 48, 359-362; in England, 362-364; in France, 364-367; in Belgium, 367-369; in Germany, 369-371.
 Bonifacio, grottoes of, described, 260-264.
 Boracic acid, jets of, 87, 112; discovery of, 115; uses of, 117.
 Bormio, baths of, described, 200.
 Borsbeck, Count Robiano de, his adventures, 317.
 Botallack tin-mine, in Cornwall, visit to and description of, 519-523.
 Boucher de Perthes, the paleontologist, remarkable researches of, described, 49-55.
 Boulaigne, intermittent spring at, described, 193.
 Bourgeois, the Abbé, fossil discoveries made by, 56, 57.

- Bowring, Dr., quotation from, 116.
 Bridges, natural, description of some remarkable, 290-292.
 Britain, Great, principal mining centres of, 95.
 CALIFORNIA, mines of, 80; how discovered, 85, 86.
 Cambrian formation, the geological character of, 21.
 Camoëns, grotto of, at Macao, 237.
 Campiglia, in Italy, alum-quarries at, 108.
 Capri, island of, its natural curiosities, 219; described by Dumas, 221; by Mendelssohn, 221-223.
 Carboniferous formation, geological character of, 25.
 Carlsbad, mineral waters of, described, 196, 197.
 Carrara, its marble-quarries described, 448, 449, 456, 457, 459, 460, 463-470.
 Castaly, the fount of, described, 173.
 Castleton, in Derbyshire, caverns of, 271.
 Cauteretz, valley of, described by Tenyson, 202.
 Caves, used as places of refuge, 228; as abodes of hermits, 229; as asylums in time of war, 230, 231; historical associations of, 233, 234.
 Cerboli, Monte. *See* LARDERELLO.
 Chalk, formation of, described, 17.
 Charivari, cave of the, described, 257.
 Cheeses, grotto of the, described, 247, 248.
 Chelsea, ice-cellars at, account of, 358.
 Chemical rocks, how formed, 17.
 Chokier, bone-cave at, described, 368, 369.
 Coal, formation of, 18; its uses, 384; discovery of, 384, 385; first workers of, 385, 386; fields of, in America, 386, 387; in Great Britain, 387, 388; in Belgium, 388, 389; in Central Europe, 389, 390; in France, 390-392; in Africa, 392, 393; in Asia, 393; confined to the northern hemisphere, 394; exploring for, 394-396; value of, 431; probable exhaustion of, 432.
 Coal-deposits in England, decrease of, 433, 434; present product of, 437.
 Coal-measures, the, fossils discovered in, 380, 381.
 Coal-mine, sinking the shaft of a, 396; excavation of, 397; how worked, 398, 399; blasting processes in, 399-401; explosions in, 401-403; disasters in, 403-412; new machinery at work in, 438-440.
 Colonnata, in Italy, marble-quarry at, 470.
 Colonna, Vittoria, allusion to, 137.
 Conington, his translation of Virgil's "*Æneid*" quoted, 124.
 Cotton, Charles, quoted, 273.
 Crawley-Rocks, cave of, described, 364.
 Creech, his translation of Lucretius, quoted, 124.
 Cretaceous formation, the, geological character of, 26, 27.
 Crozon, in Brittany, caves of, described, 254-256.
 Cumæ, ancient settlement of, 217; famous Cave of the Sibyl at, described, 217-219.
 Cuvier, the naturalist, reconstructs the Mosasaurus, 35; his theory of the earth's formation, 39.
 DELIUS, fanciful theory of the vegetation of gold by, 63.
 Deltas, formation of, described, 14.
 Deposits, aqueous and terrestrial, how formed, 14.
 Derivative rocks, formation and character of, 13.
 Descartes, his theory of the origin of springs, 195.
 Desnoyers, the naturalist, his views upon bone-caves, 48.
 Dessoubre, the river, in France, cascades of, 286.
 Devil's Hole, cavern of the, in Derbyshire, described, 271-275.
 Devonian formation, the, geological character of, 23.
 Dorat, the French poet, quotation from, 305.
 Doumaïsallais, the Bauoumas de las, or Grotto of the Demoiselles, described, 299-304.
 Drayton, Michael, his "*Polyolbion*" quoted, 547.
 Drugun, the river, in France, cavernous source of, 286.
 Dumas, Alexander, his description of the Blue Grotto of Capri, 221-224.
 ECHENOZ, bone-cave at, described, 365.
 Eldon Hole, Derbyshire, cavern of, described, 273.
 Elephas meridionalis, fossil of, discovered, 57.
 Eocene formation, geological character of, 27, 29.
 Eruptive veins, their character described, 68.
 Esparto grass, its various uses, 82, 83.
 Etretat, grottoes of, described, 257-260.
 Extinct forms, remains of, 40.
 FINGAL'S CAVE, in Staffa, sonnet on, by Wordsworth, 241, 242; dimen-

- sions of, 245; Scott's poetical description of, 246.
- Fire, supposed sea of, in centre of the globe, 62.
- Fontenelle, quotation from, 383.
- Forests, submarine, examples of, 378.
- Fossils, value of, 33; where found, 34; origin of, 35; discoveries of, 51-57.
- Fountains, leaping, 189-191.
- Fouvent, bone-caves at, 365.
- France, mining centres of, 95.
- GAILENREUTH, bone-cave at, described, 369, 370.
- Garrigou, M., his scientific discoveries, 56.
- Gastein, the mineral waters at, described, 201.
- Geysers, the, in Iceland, description of, 140; by Lord Dufferin, 140-142; in New Zealand, account of, 143-157.
- Giraud, the buried-alive, story of, 408, 409.
- Globe, the, internal heat of, 158, 159; experiments on the temperature of, 159, 160.
- Gold, vegetation of, 63; in Great Britain, 527; in Australia, 529, 530; in Europe, 532; uses and properties of, 532, 533.
- Grace-Dieu, glacier of the, described, 345-351.
- Great Tom of Lincoln, in Derbyshire, cavern of, described, 275.
- Grenelle, in France, *Artesian well* at, 160.
- Grotto del Cane, in Naples, properties of the, 128; description of, 129-131.
- Gypsum, geological character of, 18.
- HAN-SUR-LESSE, the, grotto of, described, 312-316.
- Hercyna, the river, and its sources, 214, 215.
- Hippocrène, origin of the fountain of, 173.
- Hochstetten, the traveller, his explorations in New Zealand, 149-153.
- Holland, chief mining centres of, 95.
- Homaierangi, in New Zealand, hot springs of, 150, 151.
- Homer, his description of *Avernus* quoted, 127; of the Titan Typhœus, 137.
- Humboldt, his remarks upon springs, 191.
- Huronian formation, the, geological character of, 20.
- ICE-CAVES, account of some remarkable, 345-358.
- Ice-cellars at Chelsea, description of, 358.
- Iceland, geysers in, description and explanation of, 140-142.
- Icononzo, natural bridge at, described, 290, 291.
- Inundations, subterranean, examples of, 409-411.
- Iron caps, a miner's name for indications of metallic veins, 72, 74.
- Iron, the age of, 442; value and power of, 542, 543; its use in early times, 543; among the Romans, 544, 545; in England, 545; mines of, in Sussex, 545-547; improvements in the manufacture of, 548; production of, in Great Britain, 549; characteristics of ores of, 549; various kinds of ore, 551, 552; mines in South Wales, 552; workings of, in Europe, 553.
- JAGUA, bay of, leaping springs in the, 191.
- Jaroso, discovery of the silver-mines of, 84, 85.
- Jurassic rocks, why so called, 26.
- KENT'S HOLE, near Torquay, famous bone-cave at, 363, 364.
- Kentucky, description of the celebrated Mammoth Caves of, 319-337; the Grand Vestibule, 319; Gothic Church, 320; Chamber of the Dead, 321; Labyrinth, 321; Bottomless Pit, 322-325; Starry Chamber, 326-328; Fairy Grotto, 328, 329; Dead Sea, 330-332; the Mælostrom, 332-337.
- Kirkdale, bone-cave at, description of, 362, 363.
- Kissingen, mineral waters of, described, 197.
- Kostritz, in Germany, gypsum caverns at, 371.
- LAPLACE, his theory of the earth's formation, 39.
- Larderello, boracic acid works at, described by Simonin, 119-124.
- Lartet, M., his researches described, 55, 56.
- Laurentian rocks, why so named, 20.
- Lead, mines of, in England, 535, 536; its properties and uses, 540, 541.
- Leucogæi Fontes, medicinal waters at, described by Pliny, 134.
- Limestone, geological character of, 17.
- Livadhia, modern town of, its situation 214.
- Longara, the grotto of, described, 235; terrible story connected with, 236, 237.
- Longfellow, the poet, quotation from, 168, 169.

- Lucian, quotation from the "Dialogues" of, 213.
- Lucretius, his description of Avernus quoted, 124; on the place of springs in nature, 167.
- Luna, in Italy, celebrated for its marbles, 471.
- Lunel-Viel, celebrated bone-cave at, 365, 366.
- Lys, de la, the river, subterranean course of, 287.
- MACAULAY, LORD, his description of Tunbridge Wells, 205, 206.
- Madagascar, notes on the currency of, 97.
- Madeleine, the, grotto of, described, 250-253.
- Maestricht, the quarries at, described, 34.
- Man of the Deluge, the, strange fable of, 44-46.
- Man in the primeval world, 37; antiquity of, 40, 41; difficulties surrounding the question of the origin of, 42-44.
- Manifold, the river, subterranean course of, 290.
- Mantell, Dr., quotation from, 288.
- Marble-quarries at Carrara, 448, 449; description of the operations in, 450, 451, 458; commerce carried on in the products of, 462; consumption of, 472.
- Marienbad, the baths of, described, 201.
- Marseilles, marble-sawing works at, 460.
- Martyr, Justin, his description of a visit to the cave of the Cumæan Sibyl, 218.
- Mendelssohn, his description of the Blue Grotto at Capri, 221-223.
- Metallic ore, distribution of, 75.
- Metals, various properties of, 76.
- Metamorphic rocks, geological character of, 61.
- Meuse, the river, underground course of, 287.
- Mialet, bone-cavern at, described, 366.
- Milton, quotation from, 193.
- Mineral industry, origin of, 441.
- Mineral springs, their properties, 195, 196; description of the most celebrated, 195-206.
- Minerals, classification of, 102, 103.
- Mines, sterile, 76.
- Mining marts, where situated, 95.
- Miocene formation, geological character of, 29.
- Mississippi, the river, in North America, 14.
- Mole, the river, in England, its peculiarities, 288.
- Monsummano, grotto of, described, 249, 250.
- Monte Rotondo, boracic acid works at, 115; description of Simonin's visit to, 118, 119.
- Montioni, in Italy, alum-quarries at, 108, 109; visited by Simonin, 110-112.
- Mormons, hegira of the, 86.
- Mosasaurus, the, fossil reptile, discovery of, 35.
- Moulin - Quignon, celebrated fossil human jaw discovered at, story of, 51, 52.
- NABRIGAS, bone-cave at, 367.
- Nature, ceaseless activity of, 15; methods of working of, 379.
- Nent Head, lead-mines at, described, 538.
- Nicholson, Professor, quoted, 42-44.
- Nîmes, fountain of, described, 186, 187.
- North Foreland, chalk cliffs of the, 16.
- Nummulitic limestone, geological character of, 17, 18.
- ORAKEIKORAKO, in New Zealand, hot springs of, 152.
- Organic life, development of, 31.
- Osselles, grottoes of, 309-312.
- Otake-Puarangi, in New Zealand, hot springs of, 156, 157.
- PARIS, site of, 473; successive revolutions of nature at, 473-487; its ancient quarries converted into catacombs, 488-490; quarries in the neighbourhood of, 490, 491; properties of the so-called plaster of Paris, 492, 493; mode of preparation, 495; subterranean wealth of the city, 496; characteristics and anecdotes of the quarrymen of, 499-507.
- Pennant, the topographer, quoted, 188.
- Petrarch, the poet, quoted, 184, 185.
- Petroleum, or rock-oil, its properties, 413, 414; wells of, described, 414, 415; wells of, in America, 416, 417; considerable commerce in, 418; dangers in the use of, 421-423; as a substitute for coal, 425; as a locomotive agent, 426-430.
- Polvaccio, old Roman quarry at, 450.
- Primeval forests, character of, 383.
- Primeval landscape, imaginary picture of a, 381, 382.
- QUARRIES, descriptive details of, 443, 444.
- RAIN, phenomena of, 167; effect of, on a landscape, 168; poetical apostrophe to, 168, 169; variations in the fall of, 169, 170.

- Ravaccione, in Italy, marble-quarries at, 452-456.
 Ravenna, encroachment of the land on the sea at, 16.
 Reculver, in Kent, ruined church at, 16.
 Relics, forgery of, 54.
 Remains of early human industry described, 371-374.
 Rhône, the Perte du, description of, 287.
 Ribbon-veins, peculiarities of, 65.
 Rock-crystal, properties of, 344.
 Rocks, igneous and aqueous, why so called, 12, 13.
 Romney Marsh, how formed, 16.
 Rorotua, in New Zealand, volcanic lake of, 153.
 Rotomahana, in New Zealand, hot-springs of, 153.
 Ruapahou, in New Zealand, volcano of, 146, 147.
 SAFETY-LAMP, the, invention of, 407.
 Saint-Fond, M. de, scientific discoveries of, 34, 35.
 Sandstone, the Old Red, in Great Britain, 23.
 San Nicola, Monte di, described, 134, 136.
 Sassenage, grottoes of, 277, 278.
 Scratchell's Cave, in Isle of Wight, 268.
 Sea, the, phosphorescence of, 413.
 Shaw, John, the story of, 418-421.
 Shelley, the poet, quotation from, 177, 178.
 Silicious rocks, character of, 17.
 Siloam, the pool of, at Jerusalem, described, 193, 194.
 Silurian rocks, why so called, 21, 22.
 Simonin, M., quotations from, 89-94; and chapters ii., iii., and viii., *passim*.
 Slate—what is it? 444; quarries of, described, 444, 445.
 Socrates, story of, 39.
 Soffioni, the, account and explanation of, 112, 114.
 Solfatara, the, volcanic phenomena of, 131, 132.
 Sozay, remarkable spring at, 189.
 Spa, mineral waters of, their properties, 200.
 Spagari, grottoes of, described, 231.
 Speculator, a French, adventures of, 98, 99.
 Spezzia, gulf of, fresh-water spring in, 191.
 Springs, origin of, 166, 171, 195; described by Lucretius, 167; abundance of, 179; intermittent, 192; Descartes and Falissy upon the causes of, 195; thermal, temperature of some celebrated, 163.
 Staffa, island of, described, 243; Scallop and Herdsman at, 244; Fingal's Cave at, 244-246.
 Stalactite grottoes, remarkable, described, 292-345.
 Stanley, Dean, quoted, 174-176; 193, 194.
 Stigliano, hot springs at, 109.
 Stones, superstitious notions respecting, 101.
 Stratified veins, character of, 67.
 St. Macaire, bone-cave of, 367.
 St. Michael, Gibraltar, cavern of, 267, 268.
 St. Owen, artificial ice-cave of, 355-358.
 St. Rosalia, grotto of, 223; story connected with, 224-226; festival of, at Palermo, 226; statue of, 226, 227.
 St. Winifred, well of, in Flintshire, 187, 188.
 Stufa di San Germano, 128; di Testaccio, 139; di Caccinto, 139.
 Sutter, Captain, his discovery of the mines of California, 85-88.
 TARANAKI, in New Zealand, volcano of, 147.
 Taupo, lake, in New Zealand, described, 143, 144.
 Tennyson, quotations from, 178, 179, 202.
 Té-ta-Rata, in New Zealand, hot springs of, 154-156.
 Tiber, the river, deposits at the mouth of, 16.
 Tin, a metal of interest to Englishmen, 508; mines of, in Europe, 509, 510; in Asia, 510; Cornish mines of, described, 519-526.
 Tissandier on the probable exhaustion of coal, 432, 433; and chapter vii., *passim*.
 Tölfa, important deposits of alum at, 107.
 Tongariro, in New Zealand, volcano of, 143, 144, 146.
 Töplitz, mineral waters at, their properties, 200.
 Torghatten, the grotto of, described, 265.
 Tourane, the grottoes of, 268-271.
 Touvre, the river, formed by springs, 189.
 Triassic rocks, character of, 25.
 Trophonius, the cave of, 207; legend concerning, 208-213.
 Tuki-Tarata, in New Zealand, hot springs at, 153.
 Tunbridge Wells, associations of, 205, 206.
 Tuscany, valuable salt-mines of, 105-107.
 Tylor, Dr. E., on primitive man, quoted, 58.

- VALLE OMBRASCO**, in Ischia, thermal springs of, described, 138, 139.
- Vaucluse**, the fountain of, its associations and poetical memories, 182-186.
- Vergy**, ice-cave of, described, 351-355.
- Vibrayé, M. de**, his scientific discoveries, 56.
- Vichy**, mineral waters of, their properties, 197, 198.
- Virgil** quoted, 124, 218.
- Virginia**, natural bridge in, 291.
- Volcanic action**, effects of, 133.
- Volterra**, in Italy, alabaster-quarries at, 446-448.
- WAIKATO**, in New Zealand, hot springs in the valley of, 148-150.
- Walton**, saw-mill for marble working, by, 457.
- Water**, an important element in the composition of beautiful scenery, 172, 173.
- Werner**, his theory of terrestrial revolutions, 63.
- Whitaker**, historian of Manchester, quoted, 385.
- White, Walter**, on the Cornish mines, 525, 526; on the Allenhead lead-mine, 537, 538.
- Wieliczka**, in Galicia, town of, 239; popular legend concerning, 239, 240; salt-mines at, 240, 241.
- Wirksworth**, in Derbyshire, cavern at, 364.
- ZAMBESI**, the, coal deposits in valley of, 392.
- Zealand, New**, hot springs and volcanic phenomena of, 143-157.



